Measures of Adaptive Communication

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Abstract. Adaptive communication has been theorized to be beneficial for the efficiency of tasks involving communication. This paper describes a study where accommodating simulated agents adapted to their human partners' word choice and non-accommodating agents purposely chose different but equivalent words. Both agents adapted to message length, which, along with task completion time, was used as a dependent measure of efficiency. Human subjects paired with accommodating agents were shown to be more efficient than subjects paired with non-accommodating agents, and survey ratings of cooperativeness and ability were higher for the accommodating agents.

1 Adaptive Communication

Communication has been shown to be adaptive in lexical choice [1] and syntactic choice [2] as well as speech styles, dialect, non-verbal behavior, vocal intensity, prosody, speech rate and duration and pause length [3].

In their Communication Accommodation Theory, Giles et al. [3] describe the conditions for convergence of communication behaviors as follows:

> (1) People will attempt to converge toward the speech and nonverbal patterns believed to be characteristic of their message recipients, be the latter defined in individual, relational, or group terms, when speakers:
> (a) desire recipients' social approval (and the perceived costs of acting in an approval-seeking manner are proportionally lower than the perceived rewards);
> (b) desire a high level of communicational efficiency;
> (c) desire a self-, couple-, or group-presentation shared by recipients;
> (d) desire appropriate situational or identity definitions;
> when the recipients'
> (e) actual speech in the situation matches the belief that the speakers have about recipients' speech style;
> (f) speech is positively valued, that is, nonstigmatized;

(g) speech style is appropriate for the speakers as well as for recipients.

(2) The magnitude of such convergence will be a function of
  (a) the extent of speakers' repertoires, and
  (b) individual, relational, social, and contextual factors that may increase the needs for social comparison, social approval, and or high communicational efficiency.

Examples of accommodation can be seen in the maze game of Garrod and Doherty [1] where subjects must decide how to describe their positions in a two-dimensional maze. Some subjects came to describe their positions in a line notation, giving first the line and then their location in that line:

A: Third row two along.
B: Second row three along.

Other subjects developed a matrix notation, giving horizontal and vertical locations:

A: Correct, I'm presently at C5.
B: E1.

2 Non-Adaptive Communication

A conversational partner may be non-adaptive by failing to match the behaviors of a partner. In their Communication Accommodation Theory, Giles et al. [3] describe the "antecedents" for divergence of communication behaviors as follows:

(3) Speakers will attempt to maintain their communication patterns, or even diverge away from their message recipients' speech and nonverbal behaviors when they
  (a) desire to communicate a contrastive self-image;
  (b) desire to dissociate personally from the recipients or the recipients' definition of the situation;
  (c) define the encounter in intergroup or relational terms with communication style being a valued dimension of their situationally salient in-group or relational identities;
  (d) desire to change recipients' speech behavior, for example, moving it to a more acceptable level;

  when recipients:
  (e) exhibit a stigmatized form, that is, a style that deviates from a valued norm, which is
  (f) consistent with speakers' expectations regarding recipient performance.

(4) The magnitude of such divergence will be a function of

(a) the extent of the speakers' repertoires, and
(b) individual, relational, social, and contextual factors increasing the salience of the cognitive and affective functions in (3) above.

Most research on accommodation has focused on dependent measures of converging/diverging behavior or recipient evaluations of that behavior. Giles et al. [3] describe the "consequences" of convergence and divergence as follows:

(5) Convergence will be positively evaluated by message recipients, that is, will lead to high ratings for friendliness, attractiveness, and solidarity when recipients perceive
  (a) a match to their own communicational style;
  (b) a match to a linguistic stereotype for a group in which they have membership;
  (c) the speaker's convergence to be optimally distant sociolinguistically, and to be produced at an optimal rate, level of fluency, and level of accuracy;
  (d) the speaker's style to adhere to a valued norm;
  especially when
  (e) perceived speaker effort is high;
  (f) perceived speaker choice is high;
  (g) perceived intent is altruistic or benevolent.

(6) Divergence will be negatively rated by recipients when they perceive
  (a) a mismatch to their own communicational style;
  (b) a mismatch to a linguistic stereotype for a group in which they have membership;
  (c) the speaker's divergence to be excessively distant, frequent, fluent, and accurate;
  (d) the speaker's style to depart from a valued norm;
  especially when
  (e) perceived speaker effort is high;
  (f) perceived speaker choice is high;
  (g) perceived intent is selfish or malevolent.

In addition to affecting evaluations, some research has shown that diverging communication behavior can also lead to disagreement of propositions [4], discrimination [5], or inefficient communication [6].

3 Agent Communication Study

In a study designed to test the effect of adaptivity on efficiency, Matessa [6] used accommodating simulated agents which adapted to their human partners' word choice and non-accommodating agents which purposely chose different words. Both agents adapted

to message length, which, along with task completion time, was used as a dependent measure of efficiency.

The study had four conditions: two subjects communicating through an unrestricted text interface, two human subjects communicating through a restricted text interface, one subject communicating with an accommodating agent, and one subject communicating with a non-accommodating agent. In the study, subjects were given parts of a graph (colored shapes connected by lines) with the goal of creating a whole graph. Subjects sent text messages to describe their graph part so that all parts could be combined by both subjects. Twelve different graphs were given, so pair performance could be measured over time. The restricted interface allowed message templates to be filled in with given choices of words. Choices could be skipped with the Tab key, resulting in shorter messages.

Word adaptivity was manipulated by having two agents, one that adapted to word choice and one that purposely chose different but equivalent words. The restricted interface permitted the following choices of words:

A	topmost	small	thin	red	dot	is	above	a	topmost	small	thin	red	dot
The	bottommost	medium	round	green	blob		below	the	bottommost	medium	round	green	blob
No	leftmost	large	fat	blue	object		left of	no	leftmost	large	fat	blue	object
Our	rightmost				shape		right of	our	rightmost				shape
	middle						north of		middle				
	northern						south of		northern				
	southern						west of		southern				
	western						east of		western				
	eastern								eastern				

The directional words permit two groups of words, location-based (topmost, bottommost, leftmost, rightmost) or compass-based (northern, southern, western, eastern). Object description words permit four groups of words (dot, blob, object, shape). Accommodating agents choose words within the group chosen by their partner, and non-accommodating agents choose words outside of the group. Human subjects were found to always accommodate to their partner's word choice.

3.1 Message Length Difference

Human subjects were found to adapt to the message length of their partner. Figure 1 shows the average difference in word length of messages within partner pairs and between pairs (error bars represent standard error). Subjects solved a number of graph problems, and results were averaged over groups of three problems. Different pairs decided on different word lengths for their messages, but even with this variation pairs only had a difference of about a word in their message lengths. The difference in message length between a subject and other subjects not in the pair was found to be more than two words.

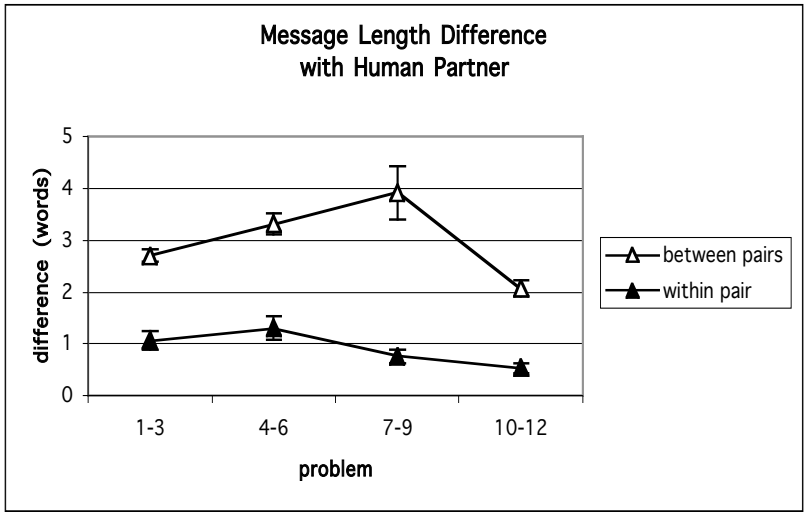

Fig. 1. Message length differences between and within human subject pairs

Similar results were found for human subjects interacting with agents. Agents were designed to always use the same number of words in a message as their partner. Figures 2 and 3 show the difference in word length of messages within human/agent pairs and between pairs.

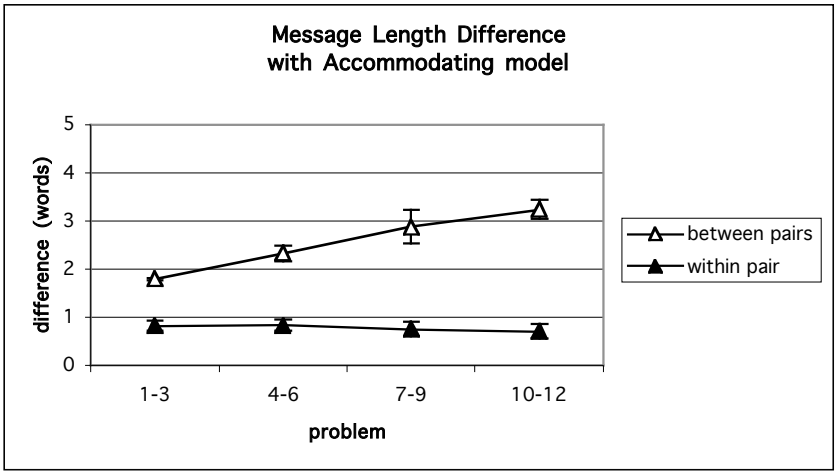

Fig. 2. Message length differences between and within human/accommodating agent pairs

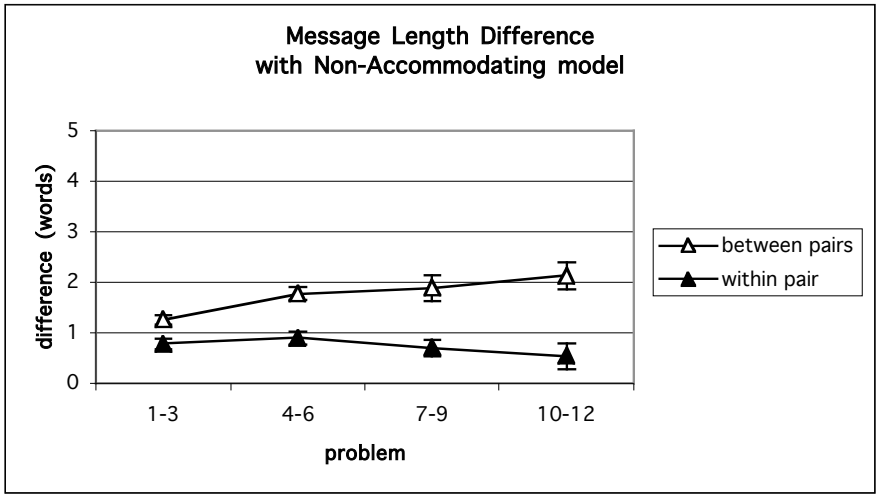

Fig. 3. Message length differences between and within human/non-accommodating agent pairs

Again, adaptive behavior is shown by the within pair difference being less than the between pair difference.

3.2 Message Length

The length of the messages tended to decrease over time. This is a standard finding in reference communication [7], [8] where communication becomes more efficient when partners continue to refer to objects over time. Figure 4 shows the average message length for human subject pairs with the restricted interface, subjects paired with the accommodating agent, and subjects paired with the non-accommodating agent. Over time, message length by human subject pairs decreased from around 11 words to around 4 words. Message length by human/accommodating agent pairs decreased from around 12 words to around 8 words. One reason for the difference between these two conditions is that the agents did not suggest message length shortenings, but rather adapted to the length of their partner. Since only one half of the pair was suggesting shorter messages, only one half of the decrease was found. Message length by human/non-accommodating agent pairs decreased from around 12 words to around only 11 words. This result is driven entirely by the human decision to not shorten message length in a response to non-adaptive word behavior.

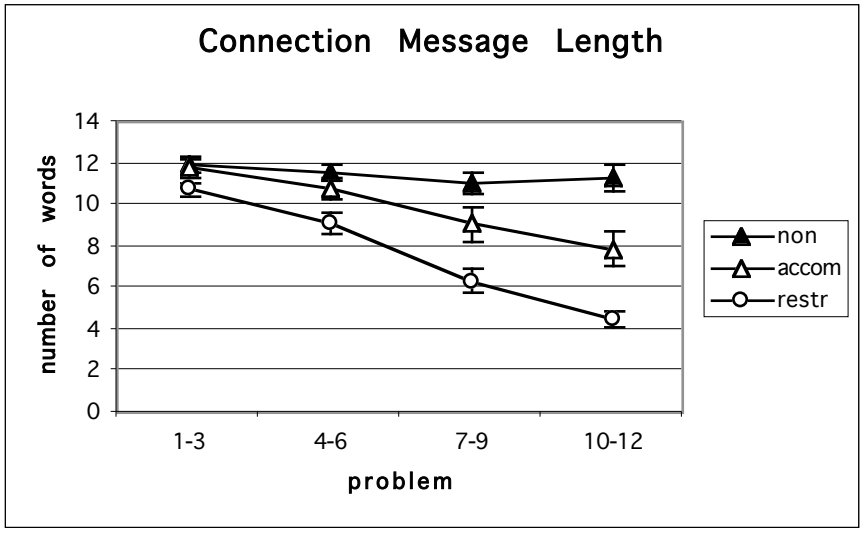

Fig. 4. Message length for human subject pairs with the restricted interface, and subjects paired with the accommodating or non-accommodating agents

3.3 Time to Solve Problem

The increased efficiency of shorter message length has effects on the larger scope of time to solve the problems. Figure 5 shows the average time to solve problems for unrestricted human subject pairs, human pairs with the restricted interface, subjects paired with the accommodating agent, and subjects paired with the non-accommodating agent. The time to solve a problem decreases over time, with the non-accommodating agent condition taking the longest, followed by the accommodating agent condition, the restricted human pair condition, and the unrestricted human pair condition. After the first problem or two in which subjects learn to solve problems and use the chat interface, the time to solve a problem is predominantly determined by message length.

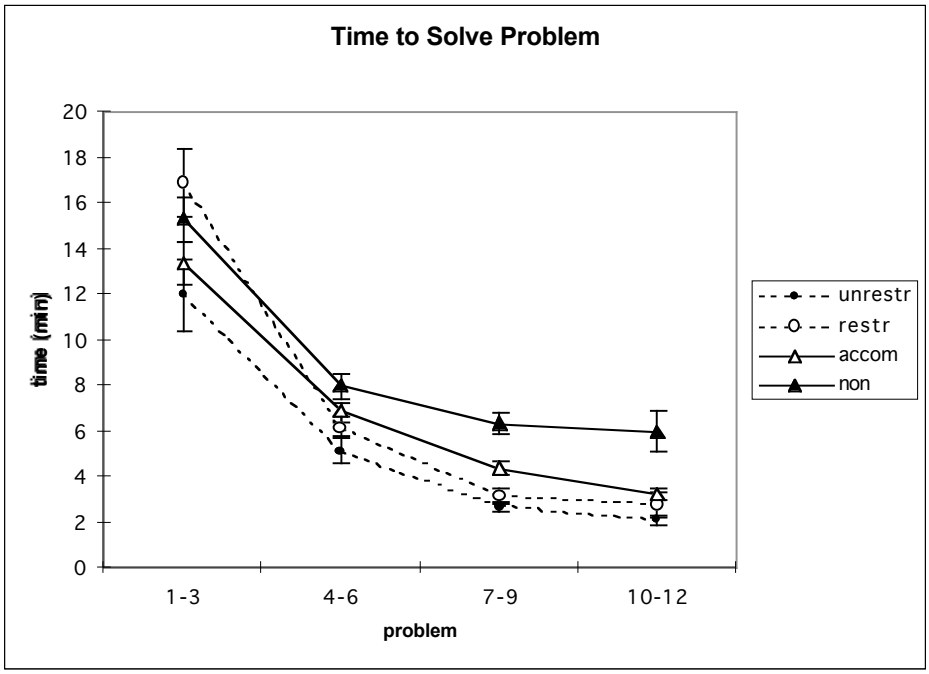

Fig. 5. Time to solve problems for unrestricted human subject pairs, human pairs with the restricted interface, and subjects paired with the accommodating or non-accommodating agents

3.4 Survey ratings

After the experiment, subjects were given a survey to rate their partner's cooperativeness and ability (and for their own self). For subjects interacting with agents, this was done before revealing the fact that their partners were not other humans. Figure 6 shows the results of this survey for subjects interacting with agents. Accommodating agents were rated higher in cooperativeness and ability than non-accommodating agents. In addition, subjects interacting with non-accommodating agents rated themselves slightly lower in cooperativeness and ability than subjects interacting with accommodating agents.

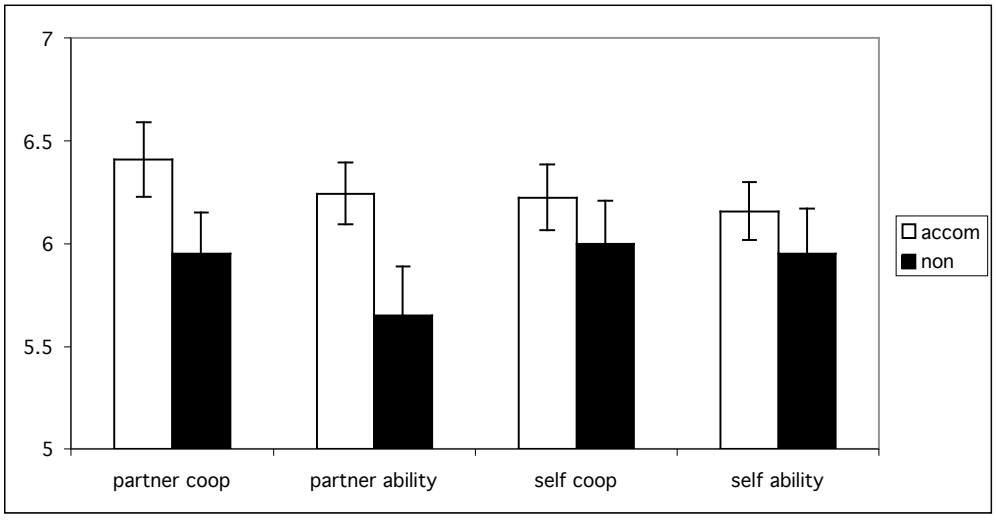

Fig. 6. Survey ratings of cooperativeness and ability for partner and self

4. Discussion and Conclusions

One of the questions proposed by this workshop is

> Can metrics be developed to facilitate the comparison between different (versions of) adaptive systems, or between adaptive and non-adaptive systems?

In this paper, message length difference, message length, time to solve problem, and survey ratings of cooperativeness and ability were used to compare human reaction to adaptive and non-adaptive agents. The agents were designed to test a psychological hypothesis (that non-adaptive behavior can be a detriment to efficiency) and so were designed to produce the simple, regular behaviors of adapting to message length and either adapting or not adapting to word choice. Therefore, the metrics used were measures of adaptive human behavior rather than agent behavior.

In general, a full evaluation of an adaptive system should include metrics of adaptivity for any adaptive part of the system (human, agent, interface, etc.) and metrics of any effects the adaptivity has on task performance, either objective (e.g. time to finish task) or subjective (e.g. ratings of cooperativeness).

References

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