Can Aristotelian Enthymemes Decrease the Cognitive Load of a Dialogue System User?

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Abstract

In-vehicle dialogue systems are gaining an increased interest in the automotive industry. Dialogue systems allow the driver to use her voice, instead of her eyes and hands, to control devices in the car and thereby increase safety. Although speech is a natural way of communicating, the dialogue itself might increase the cognitive load of the driver. In this paper we suggest a rhetorical perspective of dialogue management, using Aristotelian *enthymemes* to provide a model for analysing Information Redundant Utterances and discuss the implications this may have for in-vehicle dialogue systems.

1 Introduction

One principle according to which dialogue is managed is Grice's maxim of quantity (Grice, 1975), *do not make your contribution more informative than required*. This has often been interpreted as "make your contribution as short as possible", resulting in all utterances that may be deduced from the context or co-text being considered *Information Redundant Utterances* (IRUs). Walker (1996) points out that IRUs are often not redundant at all (thus actually adhering to the maxim of quantity rather than violating it) but instead serves to help lower the listener's cognitive load.

Using IRUs might be a way of releasing the user of a dialogue system from some of the cognitive load of the interaction itself. This can be of great importance, especially in some environments. In-vehicle spoken dialogue systems are gaining increasing interest since they enable the driver to perform secondary tasks (i.e. tasks not related to driving the vehicle) without having to take her eyes off the road or her hands from the steering wheel. Dialogue systems, unlike command based systems, also enable the driver to speak in a natural way, without having to memorise commands. The possibility of speaking freely and not having to navigate through a fixed menu structure is however not enough. Driving is a safety critical task where the driver has to concentrate on the driving (primary task) rather than the dialogue system (secondary task). Therefore it is crucial to minimise the cognitive load of the driver caused by the dialogue itself. A difficult question in this context is how to decide when to add an IRUs and when not to. Some redundancy may help relieve the working memory of the user of a dialogue system or an agent in a human-human interaction, while too much information will only increase the cognitive load. In this paper we will discuss how a rhetorical perspective may be of use in this balancing act, and suggest that *enthymemes*, as presented in Aristotle's *Rhetoric* (Kennedy, 2007), may provide a model for analysing these utterances.

The outline of the paper is as follows: First, we will discuss the notion of IRU, as presented by Walker (1996). We then suggest an approach to understanding IRUs inspired by Aristotelian rhetoric, especially the concept of *enthymeme*. In section 5 some empirical examples of arguments collected from a corpus of car-navigation instructions are presented and discussed. In section 6 we discuss the

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relation between the enthymeme and cognitive load. Finally, some conclusions are drawn and an attempt is made to formulate an agenda for further research and name some possible application areas.

2 Information Redundant Utterances

A significant feature of natural dialogue is economy. This has been noted by many scholars in the fields of pragmatics and discourse studies, and given rise to such well known and generally accepted theories as that of implicature (Grice, 1975). Walker (1996) mentions Grice's maxim of quantity as an example of a generally assumed *redundancy constraint*. Utterances that violate the redundancy constraint are referred to by Walker as IRUs. An utterance is considered an IRU if it expresses a proposition that the listener can *retrieve from memory* or *infer*. Walker argues that the redundancy constraint is based on four assumptions about dialogue:

1. Unlimited working-memory: everything an agent knows is always available for reasoning;
2. Logical omniscience: agents are capable of applying all inference rules, so any entailment will be added to the discourse model;
3. Fewest utterances: utterance production is the only process that should be minimised;
4. No autonomy: assertions and proposals by agent A are accepted by default by agent B.

According to Walker the principle of avoiding redundancy has often taken precedence in work on dialogue modelling and overshadowed other factors that affect communicative choice. Walker presents corpus data in which agents frequently violate the redundancy constraint, which indicates that the fewest utterance assumption is not correct - sometimes other aspects of communication are more important than economy.

Walker's analysis of corpus data leads her to formulate three main functions of IRUs:

- To provide evidence supporting beliefs about mutual understanding and acceptance.
- To manipulate the locus of attention of the discourse participants by making a proposition salient.
- To augment the evidence supporting beliefs that certain inferences are licenced.

Let us now take a look at one of Walker's examples of IRUs. An utterance is produced by A to B while walking to work (Walker, 1996):

(1) A: i) Let's walk along Walnut Street
ii) It's shorter.

It is known to A that B knows that Walnut Street is shorter, so by the redundancy constraint A should only have said i). Walker claims that ii) is considered an IRU based on the assumption of 'unlimited working memory', i.e. that all knowledge and information an agent has access to is equally available at all times. Walker hypothesises that the mentioning of the well-known fact that Walnut Street is shorter is a way for A to ease Bs cognitive load.

Let us take a look at another of Walker's examples. The following exchange is taken from an discussion about individual retirement accounts.

(2) A: i) Oh no, individual retirement accounts are available as long as you are not a participant in an existing pension.
B: ii) Oh I see. Well [...] I do work for a company that has a pension.
A: iii) Ahh. Then you're not eligible for [the tax year of] eighty one.

Walker's analysis of this example is that iii) is considered an IRU based on the assumption that agents are logically omniscient, since B would have to apply an inference rule to conclude iii). The function of A's stating iii) is, according to Walker, to "augment the evidence supporting beliefs that certain inferences are licenced".

3 A Rhetorical Approach to IRUs

Much work on language usage in general and dialogue systems in particular has taken rhetoric into account. Two recent examples are Miller (2003), who discusses how the notion of rhetorical ethos is central in creating an agent that is capable of passing the Turing test, and Andrews *et al.* (2006) who focus on how social cues and emotion can make dialogue systems behave more naturally. A fruitful way of

incorporating the logos-part of rhetoric in linguistic theory is as starting point for frameworks for structural analysis. Hobbs (1985), Asher and Lascarides (2003), Mann and Thompson (1986) *et al.* have presented theories for understanding textual structure (Mann and Thompson) and utterance relations (Lascarides, Asher, Hobbs). However, in much of the literature on rhetorical relations, little attention is paid, as far as we know, to the way supposedly information redundant utterances serve to add new information to the discourse situation by pointing to a specific argument.

We would like to suggest a way of looking at IRUs that elucidates Walker's ideas about the functions of IRUs, and offers an alternative to the four assumptions of the redundancy constraint. The three functions of IRUs in Walker's study have in common that they aim to lead the listener to a certain conclusion, either by supporting a belief the listener already has, or by directing, or even redirecting, the attention of the listener. In other words - IRUs are rhetorical. Examples (1) and (2) are both illustrations of this. The fact that (1ii) is considered redundant according to the redundancy constraint seems to reflect not only the unlimited working memory assumption, but also the assumption that agents are non-autonomous and by default accept assertions and proposals by other agents. The relative autonomy of B makes it possible for B not to accept A's proposition. By providing a reason for choosing Walnut Street, A performs a rhetorical act that potentially increases the likelihood that the suggestion will be accepted by B. Example (2) also indicates that A wants to make sure that B draws a specific conclusion. It seems likely that A, if she did not find it of some importance that B draws the conclusion iii), might not bother to make the inference explicit - B could still be expected to make the inference. However, for B to do that would not necessarily make her "logically omniscient" – the assumption Walker (1996) claims to be the reason for considering (2ii) an IRU – just capable of making *some* inferences.

Interestingly, many of Walker's examples of IRUs and their respective antecedents constitute structures similar to that of an Aristotelian *enthymeme*. An enthymeme can be described as a logic-like deductive argument. In the *Rhetoric* (Kennedy, 2007), Aristotle claims that learned, scientific argumentation differs from practical, hands-on argumentation concerning every day matters: when you speak to people that are not experts in the area you are dealing with, and who do not have much experience with logical reasoning, it is, according to Aristotle, inefficient to present long chains of logical arguments. In persuasion he therefore recommends shortening the arguments, which results in them not being strictly logical. However, Aristotle still emphasises the logos-based, deductive nature of the enthymeme, and calls it "a sort of syllogism" (Kennedy, 2007). The premises needed to make an argument a "real" syllogism, is added by the listener from her knowledge of culture, situation and co-text (what has been said earlier in the speech or conversation), according to a "pattern" known as the *topos* of the enthymeme. This pattern can be very general assumptions based on physical parameters such as space (the small can be contained in the big), or more specific assumptions such as prejudice about people belonging to a certain group. The mentioning of one carefully chosen premise directs the attention of the listener in the direction that the speaker wants, and makes the listener a bit more likely to accept the proposition presented in the conclusion. The enthymeme might of course serve to persuade or even mislead a listener, but the same mechanism can also make it easier for an agent A to accept an honest and constructive proposal made by another agent, which would be helpful when quick decisions need to be made, or when A has to focus on some demanding parallel activity.

Let us go back to the colleagues walking to work. Example (1) above could easily be analysed within a rhetorical framework. Mentioning (1ii) could be a way for A to point to the argument about the shortest route, perhaps because they are running late. There could be other reasons to walk along Walnut Street, perhaps that it is more quiet. A might know that B usually prefers a busy street, but that she does not particularly like to walk, which would make the short-argument more persuasive. If they were not in a hurry, and A wanted them to walk along Walnut Street because it is nicer to walk along a quiet street than a busy one, A would probably say 'Let's walk along Walnut Street. It's more quiet' thus validating her suggestion. But it

is also possible that A would want to walk along Walnut Street for some reason that she does not want B to know about - for example because someone cute always walks his dog there at that time. So, even though she knows that B knows it is the shortest way to work, A still mentions it to point out the getting-to-work-on-time argument. The enthymematic argument looks something like this:

It's shorter
We want to go get to work on time

$\therefore$ Let's walk along Walnut Street

The "hidden premise", i.e. the premise that B adds to the argument, would be something that makes sense in the context, having to do with for example time (as above) or effort (we don't want to walk longer than necessary).The additional premise is necessary in order to make the enthymeme fit with the relevant topos. This is also true in the case of (2), where two premises are expressed, but the expressed premises do not logically entail the conclusion.

Individual retirement accounts are available
as long as you are not a participant in
an existing pension
I do work for a company that has a
pension

$\therefore$ (Then) you're not eligible for
eighty one

A rhetorical perspective that uses enthymematic arguments as an explanation model for how information is given and withheld, would be based on a different set of assumptions about dialogue than those Walker formulates as the basis of the redundancy constraint. Thus we propose the following rhetorical principles

1. Limited working-memory: suggestions help agents to reach a certain decision

2. Logical capacity: agents are capable of applying some inference rules, some entailments will be added to the discourse model;

3. Utterance production: should be balanced so as to maximise persuasion

4. Autonomy: assertions and proposals by agent A are not accepted by default by agent B, and different agents may or may not share goals and intentions.

4 Enthymemes in Car Navigation Instructions

In a data collection carried out within the DICO project (http://www.dicoproject.org)[1], a driver is given navigation instructions by a passenger, in between the instructions the passenger interviews the driver about personal matters such as favourite food, number of siblings, favourite holiday resort, etc. The aim was to study human-human in-vehicle conversation with respect to how humans adapt the way they speak to the cognitive load of the other dialogue partner. The data includes examples of enthymematic arguments, of which some are also IRUs according to Walker's definition.

(3) A: i) Vi håller höger här på (*Let's keep to the right here*)
ii) Så vi kan...byta (fil) (*So we can...change (lanes)*)

Example (3) is uttered by a passenger (who provides the driving instructions) in a situation where both driver and passenger know that it is time to keep to the right in order to be able to change lanes. The passenger has stated a minute or so earlier that they should change to the right lane. Considering the information the driver has about the traffic situation and the previous instructions given by the passenger, (3ii) should not be necessary according to the redundancy constraint. (3) can also be seen as an enthymeme:

So we can...change (lanes)
In order to change lanes we have to keep to the right

$\therefore$ Let's keep to the right here

(3i), the proposition that they should keep right, is the conclusion of the enthymeme and the explicit premise (3ii) (they want to change lanes). The

[1] DICO is a project that aims to demonstrate how state-of-the-art spoken language technology can enable access to communication, entertainment and information services as well as to environment control in vehicles. A priority in the project is cognitive load management for safe in-vehicle dialogue.

non-explicit premise is something like 'if we are to change lanes we have to keep to the right', which is a fairly general assumption about spatial relations - the topos of the enthymeme.

(4) *A*: i) Rosengatan ja det måste vara nästa (*Rose Street yes it has to be the next*)
ii) för vi kommer inte så mycket längre (*cause we don't get much further*).

In example (4) it is clear to the driver that the street is ending. By supplying the premise (4ii) he points to an enthymematic argument based on a number of premises, most of which have been stated earlier (for example that Rosestreet crosses the street they are driving down), and one that has to be inferred (if you know that a street crosses the one you are driving down, and you haven't yet past it, and there is only one street left, this has to be the street you are looking for).

We have also looked at data recorded for the purpose of a master thesis about car navigation instructions (Caroline Bergman, work in progress). In this case the instructions are given over the telephone by a person with access to maps and driving instructions on the internet.

(5) *A*: i) Ta till vänster vid Redbergsplatsen
ii) står det här ja. (*turn left at Redbergsplatsen it says here.*)

Example (5) demonstrates the need to motivate for rhetorical purposes rather than to provide new information about one's reasons. The driver is well aware that the instructor is using a map and written driving instructions to be able to help the driver navigate. Still the instructor repeatedly validates her instructions by stating that the map or other instructions 'says so'. It seems probable that the driver has reason to be suspicious of the instructions, since the person giving them is somewhere else and does not have access to any information about the traffic situation that the driver does not provide.

5 Cognitive Load and Efficiency

As humans we need reasons to validate propositions we are presented with. We know this intuitively – it is difficult to complete a task if we are just presented with single pieces of information that do not seem to be connected. The same conclusion can be made based on different premises, and we often want to know which argument the speaker is referring to before we accept a proposition. There are situations where the standard way to instruct is by single utterances (or orders), such as in the military, or in other contexts where the roles are very well defined, and the *modus operandi* of the activity well rehearsed, such as in surgery. We agree with Walker's conclusion that IRUs serve to ease cognitive load in different ways. Our hypothesis is that the reason why they do this is often because the enthymematic structure helps the recipient of the IRU to make up her mind - if the provided premise fits into an argument she finds acceptable she will agree with the proposition, if not she will disagree. Neys and Schaeken (2007) show that the tendency to make logical rather than pragmatic inferences increases when under heavy cognitive load, which indicates that pragmatic inferences use more working memory. This supports the idea that it would be good to present arguments in a form resembling a logical argument rather than just presenting the proposition - even if the recipient is aware of the information in the premise (IRU) provided.

6 Concluding Remarks

Studying in-vehicle conversations reveals that interacting with someone while driving is always distracting (see e.g. Patten *et al.* (2003)), and sometimes dangerously so. Conversation increases the cognitive load of the driver and thus prevents her from fully focusing on the primary task of driving. Studies of cell phone conversations have revealed that the major reason why cell phone conversation is dangerous is not the handling of the cell phone (i.e. the use of hands free cell phone is not safer than a manual cell phone), but the conversation itself increases the cognitive load of the driver to such an extent that the risk of an accident increases (Redelmeier and Tibshirani, 1997). Most user studies carried out to measure cell phone conversations impact on driving behaviour are carried out in car simulators, and the parallel task is to perform mental processing tasks such as arithmetic operations.

These studies point at a significantly decreased driving performance. Esbjörnsson *et al.* (2006) on the other hand, studied real cell phone conversations in cars driving in real traffic. They found that in human-human conversation the dialogue partners have strategies for dealing with distraction and increased cognitive load. Humans tend to 1) sense when a particularly stressful situation is coming up and adjust by, for example, pausing the conversation and 2) generally use the conversational "rules" that keep verbal interaction running smoothly – after all, keeping a conversation going in any situation adds to the cognitive load of the speakers. However, in the context of in-vehicle conversation with a dialogue system we can normally not expect this kind of adjustment. The system can be compared to a *remote caller* (Schneider and Kiesler, 2005), i.e. a dialogue partner not sitting in the passenger seat but speaking to the driver over the phone and thus does not have access to the traffic situation. Problem 1), that of detecting and managing particularly stressful situations, is not addressed in this paper. Instead we have focused on a way to potentially minimise the cognitive load that is caused by the conversation itself.

A rhetorical perspective provides a model for interaction that works for interactions in a context where the agents do not necessarily have a common goal or intention. The mechanisms that enables persuasion, can also be used in order to explain something in an easily comprehensible way. A skilled rhetorician is often also a skilled teacher, since it is easier to understand something if one understands the argument behind it. In the context of a dialogue system that is advanced enough to be able to handle conversation that is to a certain degree “free”, a rhetorical perspective would be beneficial. This would be the case for contexts when the system has an agenda distinct from that of the user, e. g. to make the user buy something or convince the user about the importance of a healthy lifestyle. In a domain such as car navigation, where user and dialogue system have a common goal, it might still be beneficial for the system to be able to provide a premise that points to an argument that would explain its reasons for giving a certain answer or instruction. Such premises would be helpful not only in situations where the system adds new information, such as if the user has asked for the quickest route and the dialogue system proposes a route that does not seem to be the shortest possible, and the system explains that some roadwork is going on or there is a one-way street along the shortest route, but also in situations where the contribution serves a rhetorical purpose rather than an informational one. The system’s pointing to an enthymeme relevant to the situation may make it easier for the driver to decide whether to accept the instruction or not. This potentially minimises the cognitive load since the driver has to make fewer inferences, but still is not overloaded with all the evident premises of strictly logical reasoning.

7 Future work

In future work, we plan to further analyse data collections carried out in the DICO project, and investigate how enthymemes and IRUs are used in human-human dialogues. In addition to this we would like to perform an experiment where subjects are instructed to solve an ethical problem online. Based on the results a repetition of the experiment could be performed where subjects are divided into two groups. In this second part of the experiment the conversations will be manipulated. One group will be provided premises such as were given by subjects in part one, the second group will get premises that do not make sense. This kind of experiment would allow us to compare the decision making capacity in the two cases. Hopefully it would also give information about when it is beneficial to motivate a proposition and what kind of information should be supplied. The results of DICO data analysis and experiments will possibly show some regularities similar to the notion of topoi, and might give an idea about which enthymemes a car navigation system should be able to point to.

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