Efficiency and Effectiveness in Task-Oriented Dialogue:
On Construction Repetition, Information Rate, and Task Success

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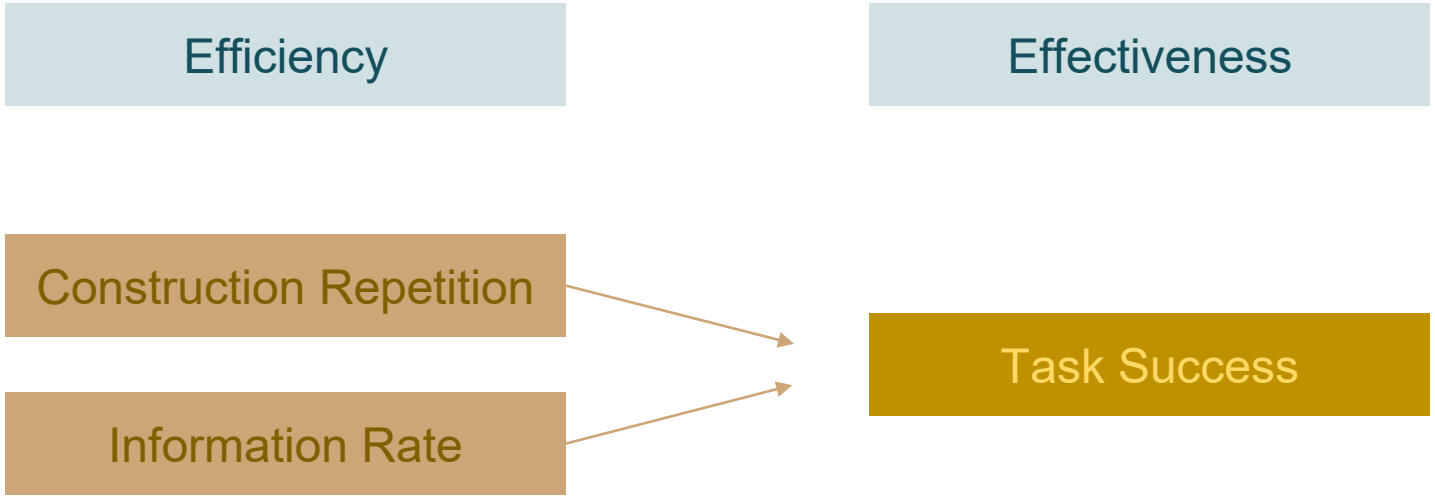
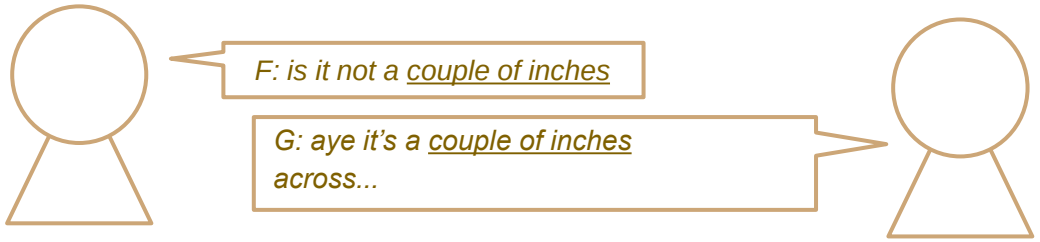
Construction Repetition, Information Rate, Task Success

Effective task-oriented dialogues must balance efficiency with informativeness

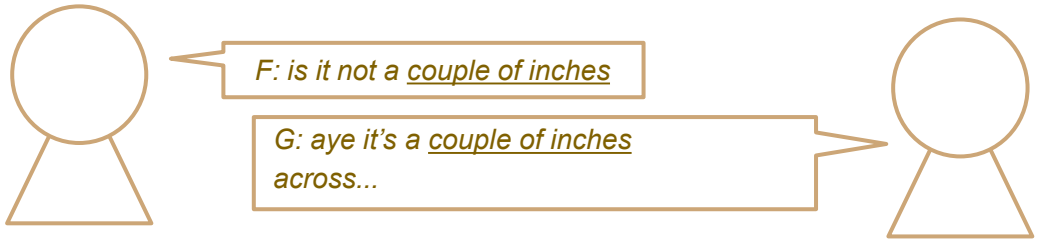


Repetition and Coordination in Dialogue



The coordination and repetition of shared linguistic forms allows speakers to collaboratively establish and maintain common ground (Pickering and Garrod, 2004b), to develop particular partner-specific language, and of that, reuse effective formulations (Brennan and Clark, 1996).

Processing Effort and **Information Rate** in Dialogue



We take the information-theoretic notion of information content or **surprisal** (Shannon, 1948) as a measure of processing effort.

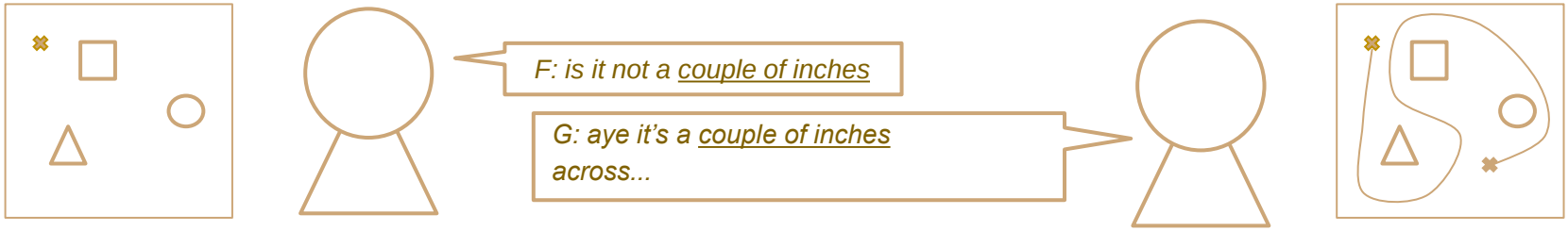
In dialogue:

- surprisal has been found to converge between speakers (Xu and Reitter, 2018)
- surprisal depends on contextual unit and speaker role (Giulianelli et al., 2021)
- speakers have been found to coordinate how information dense their language is (Xu and Reitter, 2017).

Map Task: navigational instruction task

Instruction Follower

Instruction Giver



Task: Without seeing each other's maps, the instruction giver describes how to follow the route drawn on their map, follower draws this route on their own, blank map

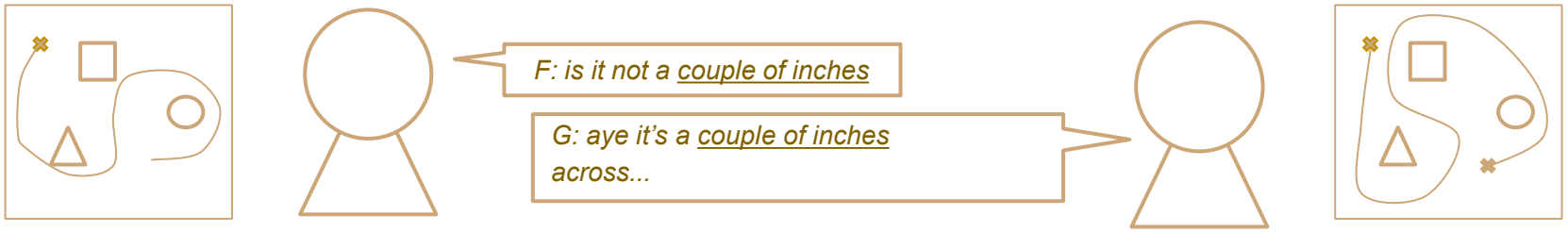
Success measure: Instruction follower's route matches the route of the instruction giver as closely as possible

HCRC Map Task Corpus (Anderson et al., 1991). https://groups.inf.ed.ac.uk/maptask/

Map Task: navigational instruction task

Instruction Follower

Instruction Giver



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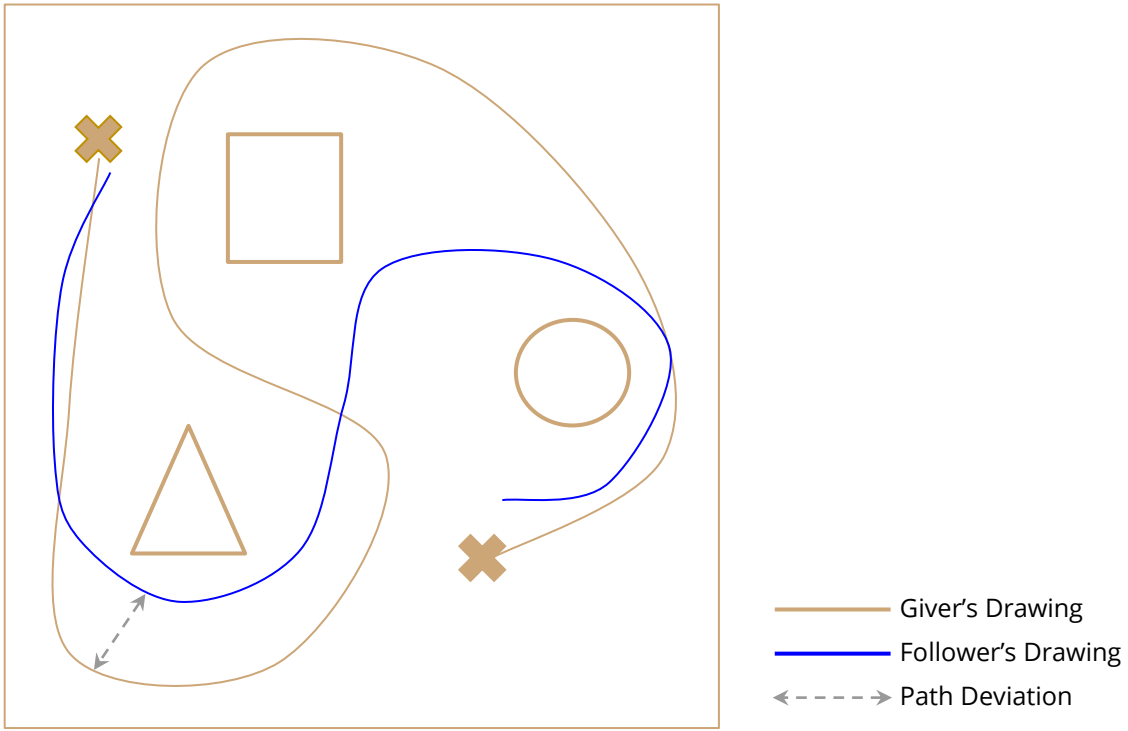
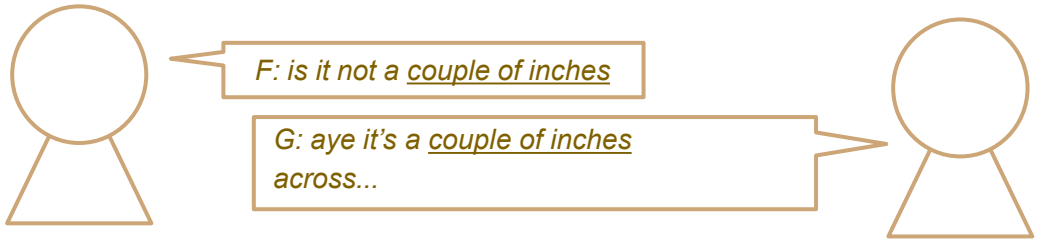


Repeated constructions in dialogue



Constructions: sequences of three or more tokens (excluding punctuation), repeated at least three times in a dialogue

Constructions serve different communicative functions

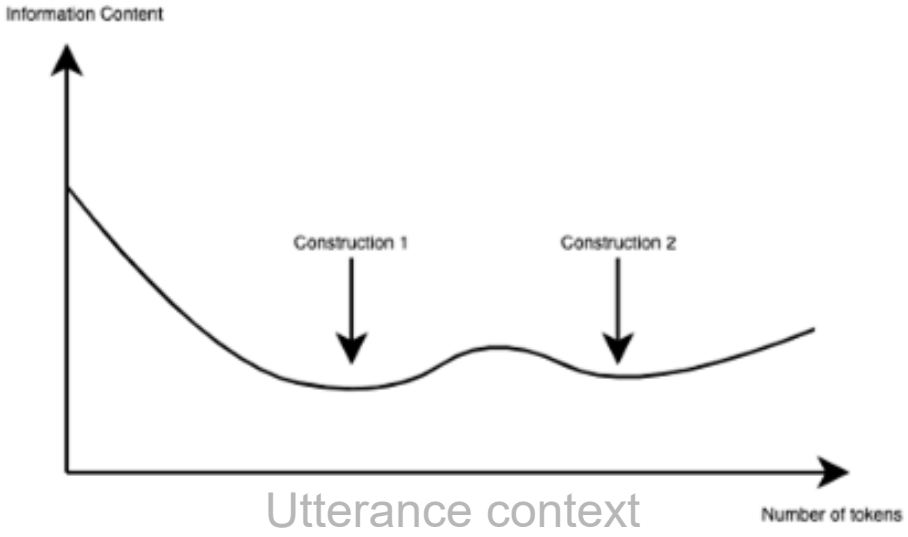
Landmarks	***Directions***	***Generic***
the rope bridge	the left-hand side	do you have
the white mountain	about an inch	there's a
the diamond mine	of the page	I've got a
the gold mine	to the right	have you got
the trout farm	the top of	I've got
the slate mountain	side of the	have you got a
of the mountain	about three inches	do you have a
the dead tree	to the left	you're at
of the stile	the top of the	until you're
the carved stones	to your left	I don't

- Task specific (Landmarks and Directions)
- Generic (non-referential

Constructions vary in information content

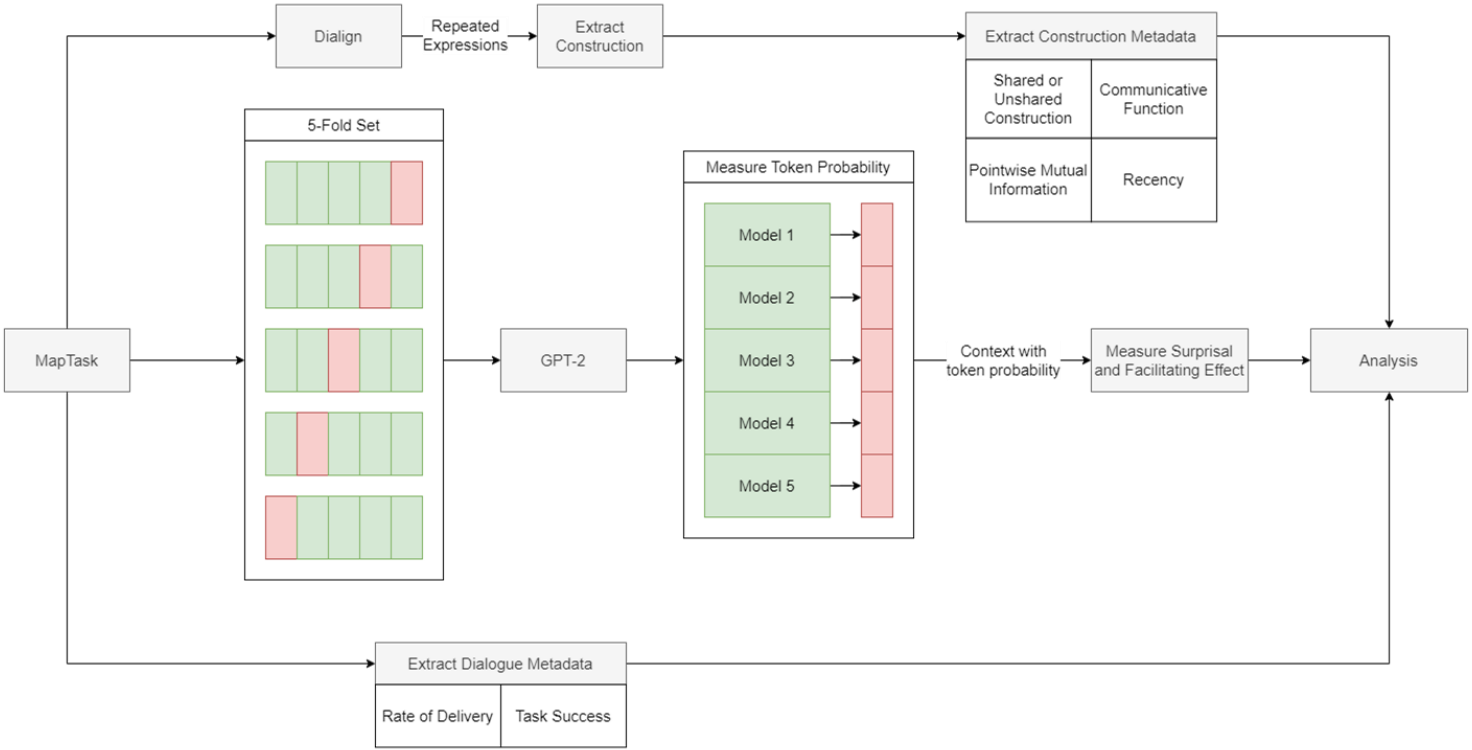
Construction Surprisal: average per word surprisal

Facilitating Effect: the change in surprisal contributed by a construction to its containing utterance



Facilitating effect is positive when the surprisal of a constructionis lower than the surprisal of its utterance context

Experimental Pipeline



Results: Efficiency and Repetition

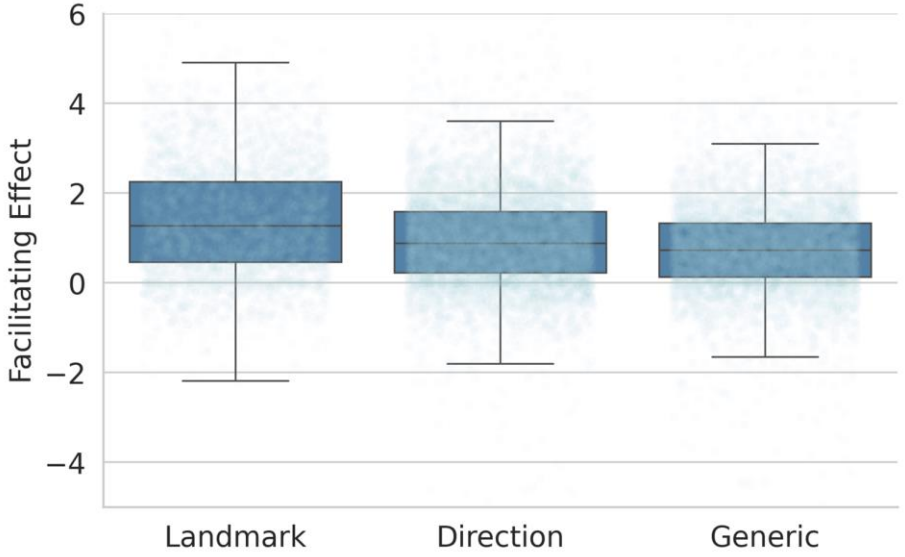
Efficiency and Repetition

Construction repetition facilitates processing in task-oriented dialogue

- Construction use reduces information rate.
- Construction repetition has facilitating effects.
- Facilitating effects of construction repetition are cumulative and decay.

A Construction's Communicative Function Affects Repetition Efficiency

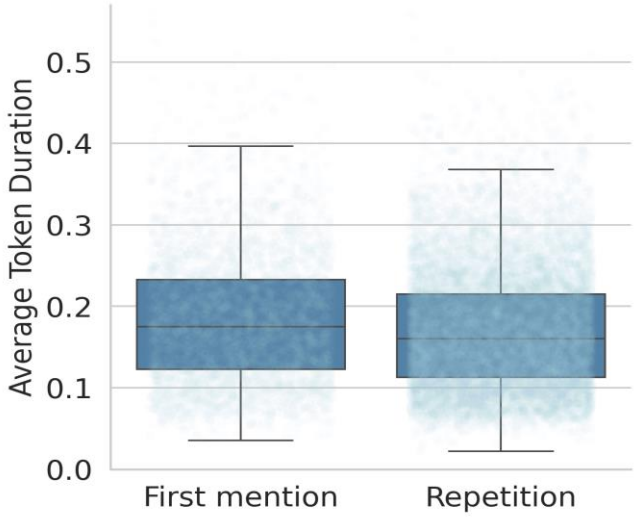
- Task-related repetition shows higher facilitating effect.

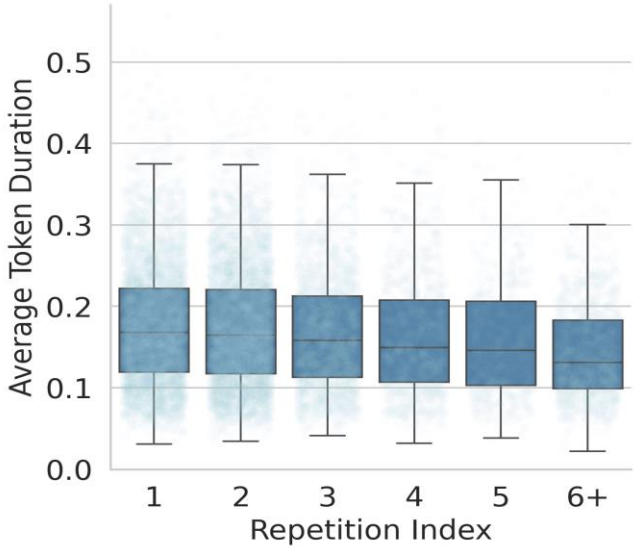


Efficiency and Repetition

Repetition affects Rate of Delivery

- The more redundant the repetition, the higher the speed of delivery
- Surprisal duration trade-off coexists with extended Facilitating Effect.





Analysing Effectiveness: Efficient Strategies for Task Success

Predicting task success

We define task success as the normalised inverse of the path deviation score **Pathdev**.

As predictors of task success, we consider factors capturing different aspects of efficient language use: surface-level patterns of repetition, information rate, and duration.

Models:

1. Base: dialogue length and duration, construction usage properties, information rate properties
2. (1) split by **Communicative function**
    a. (2) split by **shared Vs. unshared** constructions
    b. (2) split by **speaker role**

Predicting task success

Base: dialogue length and duration, construction usage properties, information rate properties

→ does not distinguish between communicative function, whether the construction is shared or the role of the speaker

We find only the dialogue length (total number of tokens) is a significant predictor of success

We therefore then consider the same predictors:

1. split by **Communicative function**
    a. Further split by **shared Vs. unshared** constructions
    b. Further split by **speaker role**

Communicative function

We expect task-related repetition (i.e., landmark and generic) to be important to success (Norman et al.,2022).

We find that **effective** dialogues are characterised by speakers using:

- Less surprising constructions referring to landmarks
- Direction constructions with increasing facilitating effect

Information rate management strategies for **task-related** constructions indicate that processing efficiency is an important predictor for task success.

- More surprising and facilitating generic constructions

While also facilitating, task-agnostic constructions can be both effective and informative.

Shared Vs. unshared constructions

We expect different efficient strategies to be predictive of task success for shared vs. unshared constructions: that shared constructions can indicate the development of shared routines, allowing speakers to establish common ground, while self-repetitions can relate to processing efficiency in language production.

We find that **effective** dialogues are characterised by speakers using:

Unshared	
Landmarks: Less surprising, longer, less frequently repeated Directions: less dialogue specific	Longer, less surprising references to landmarks may be easier to resolve, and thus less likely to need to be repeated, while familiar common direction vocabulary is more effective
Generic: More surprising over time	The information rate of task-agnostic repetitions may be less important to effectiveness.

Shared Vs. unshared constructions

Shared constructions can indicate the development of shared routines, allowing speakers to establish common ground.

We find that **effective** dialogues are characterised by speakers using:

Shared	
Overall: Greater proportion of shared constructions	In line with our predictions, the development and reuse of shared routines is a characteristic of successful dialogue.
Landmarks: less diverse, shorter, less surprising lower facilitating effect Directions: longer, fewer, not local (e.g. re-used across the dialogue	These results could result from both speakers making short confirmatory repetitions. Unlike unshared direction constructions, more surprising directions are effective if they are repeated by both speakers.
Generic: frequently reused across the dialogue, lower facilitating effect, more surprising with re-use	These may allow speakers to establish rapport (Cappella,1990) and common ground, which our measures do not directly capture.

Speaker Role

Successful strategies are likely to vary by speaker role, whether the instruction giver, or the instruction follower.

We find that **effective** dialogues are characterised by speakers using:

Instruction Giver	Instruction Follower
Landmarks: more unique, increased facilitating effect over time	Landmarks: fewer unique, not dialogue specific
Directions: frequent	Directions: lower surprisal, lower facilitating effects
Generic: longer, more surprising, increasing in facilitating effect	Generic: local repetition

Speaker Role

Successful strategies are likely to vary by speaker role, whether the instruction giver, or the instruction follower.

We find that **effective** dialogues are characterised by speakers using:

Instruction Giver	Instruction Follower
Landmarks: clearer use from the giver, follower doesn't need to repeat to confirm as much resulting in better integration of constructions into the common ground	
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Generic: use is more of a balance between efficiency and effectiveness: including more information, at a higher information rate, while controlling for processing cost. Local repetition important for followers, longer more surprising repetitions that have high FE for givers.	

Summary

We investigate the roles that efficiency and effectiveness play in speakers' repetition of shared word sequences, or constructions, in task-oriented dialogue.

We find:

- repeating constructions has negative effects on information rate and positive effects on rate of delivery
- that information rate managing strategies are predictive of task success, and that this varies by the communicative function of the constructions being repeated.
- more effective dialogue is characterised by greater levels of shared construction usage and more efficient task-related repetition
- while task-agnostic repetition can seem redundant, it can serve important efficiency and effectiveness functions.

Our results highlight the importance of repetition and of developing a shared lexicon for both efficiency and effectiveness in task-oriented dialogue.

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