Combinatorial Dialogue Authoring

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Abstract. We present an annotation scheme and combinatorial authoring procedure by which a small base of annotated human-authored dialogue exchanges can be exploited to automatically generate many new exchanges. The combinatorial procedure builds recombinant exchanges by reasoning about individual lines of dialogue in terms of their mark-up, which is attributed during annotation and captures what a line expresses about the story world and what it specifies about lines that may precede or succeed it in new contexts. From a human evaluation task, we find that while our computer-authored recombinant dialogue exchanges are not rated as highly as human-authored ones, they still rate quite well and show more than double the strength of the latter in expressing game state. We envision immediate practical use of our method in a collaborative authoring scheme in which, given a small database of annotated dialogue, the computer instantly generates many full exchanges that the human author then polishes, if necessary. We believe that combinatorial dialogue authoring represents an immediate and huge reduction in authorial burden relative to current authoring practice.

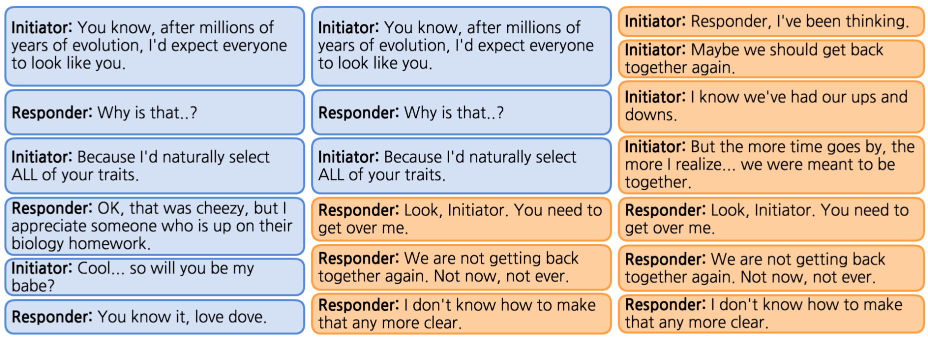
Keywords: dialogue · natural language generation · authorial burden

1 Introduction

Dialogue is a compelling storytelling mechanism and excellent way of expressing states that underly interactive-narrative systems, but telling a story with dialogue entails a large authorial burden. It is infeasible to anticipate all the potential states that a dynamic system might get into, let alone to write fully realized dialogue for each of them. Indeed, current dialogue authoring practice for digital storytelling systems is widely seen as inhibiting advancement of the latter [18, 9]. Even many systems that do use language to storytell or to express underlying state have eschewed fully realized character dialogue by instead relying on expressive abstractions of language, examples being *Storytron* with its Deikto words [3] and the Simlish of *Sims 3* [4]. We envision a future in which autonomous characters in dynamic story worlds come up with their own dialogue from scratch by reasoning over rich representations of meaning and intent—but that future is not here yet. As a step from current authoring practice toward this ideal, we present a technique in which dialogue segments carry their own specification of why and where they may be used, allowing authors to write fewer lines of dialogue that are used more often. We call this technique *combinatorial dialogue authoring*, and demonstrate it using dialogue written for a system called *Comme il Faut*, or *CiF*.

CiF is a social artificial-intelligence engine that is designed to underlie interactive narrative experiences in which the player's primary affordances are social interactions with or between characters [11]. The system's major demonstration to date is *Prom Week*, a social-simulation videogame set in a high school in the week leading up to prom. In each level of the game, *Prom Week* players are tasked with causing certain social outcomes to be realized before the titular prom concludes the week. These outcomes may be for two characters to begin dating or to become friends, for example, and are achieved by selecting social interactions, like *flirting* or *bragging*, that are initiated by one character and directed toward another. Once a particular interaction, or *social exchange*, and initiating character, or *initiator*, are selected by the player, *CiF* reasons over several thousand social considerations to decide whether the recipient of the exchange, called the *responder*, will accept or reject it. This computation is then repeated to choose an *instantiation* of that exchange to play out. An instantiation is an enactment of a social exchange through around five to ten lines of hand-authored dialogue between its participants, with *preconditions* on it specifying things that must be true about the story world in order for it to be enacted.

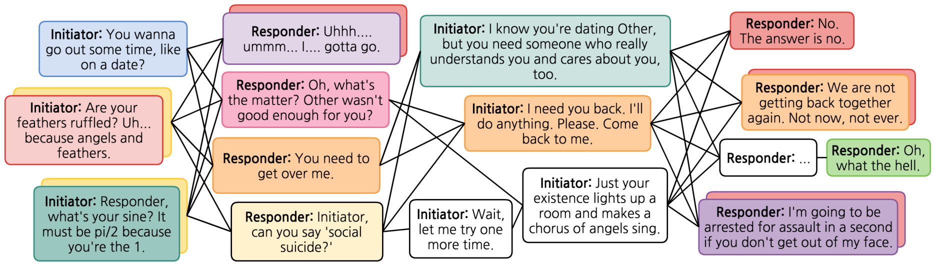
Fig. 1. A simple recombinant *Prom Week* instantiation, middle, culled from two existing human-authored instantiations.



Like all systems that use dialogue to storytell and express underlying state, *CiF* plays victim to the authoring bottleneck, which in this case has worked to limit the total number of instantiations hand-authored for *Prom Week*. This limitedness of the full set of instantiations in turn limits coverage, in terms of what can be expressed, of the possible social states represented in *CiF*, the multitude of which is largely the selling point of the system.

So, what can be done? We present an annotation scheme and combinatorial authoring procedure by which a small base of annotated human-authored *Prom Week* instantiations is exploited to automatically generate new recombi-

Fig. 2. A mere sixteen lines of dialogue are exploited to generate 75 unique *Prom Week* instantiations, shown here as full graph traversals. Each serves a unique purpose (represented by the set of colors passed through) not fulfilled by any existing instantiation.



nant instantiations—like the one shown in Figure 1—that satisfy targeted constraints. Figure 2 illustrates how our method can harness a very small base of dialogue segments to generate many new exchanges. This task is not trivial, as it requires the computer to reason about how dialogue may be used to express very specific aspects of game state and how to ensure that adjacent lines of dialogue cohere. While the work we report is specifically for *Prom Week*, our method of combinatorial dialogue authoring is generalizable to any systems that use dialogue to express underlying state, particularly those whose dialogue exchanges are directed and specify a resulting state change.

Prior work has explored repurposing natural-language text for a number of applications, including story generation [17], chatbots [2], interactive tutoring [12], pedagogical simulation [7], and spoken dialogue systems [15]. While these projects involve recontextualizing language content, our approach might instead be characterized as *decontextualizing* language content, specifically dialogue, such that its usage in the very work for which it was composed becomes less constrained. Other related work has involved expressive natural language generation for digital storytelling [18, 13], but by unrelated methods. The most similar work that we know of is the Versu project [6], in which techniques comparable to ours, including speech-act attribution [16], are used to compose character dialogue exchanges on the fly. Our method, while similar, is instead intended to alleviate authorial burden during the composition of dialogue *prior* to runtime, and also to be generalizable to any system. Combinatorial dialogue authoring was first proposed in [14].

In the following section, we describe our annotation scheme. Section 3 outlines our combinatorial authoring procedure, and Sections 4 and 5 show example generated recombinant instantiations and present the design and results of an evaluation procedure comparing these to human-authored instantiations.

2 Annotation Scheme

We take existing human-authored *Prom Week* instantiations and annotate their individual lines of dialogue for what they express about the story world and, because dialogue is not freely recombinable, their specifications about lines that may precede or succeed them in new contexts. More specifically, we annotate lines for the social-exchange identities (e.g., that a *Pick-up line* exchange is being enacted) or outcomes (e.g., that the responder is rejecting the core purpose of the social exchange), if any, that they communicate; instantiation preconditions (e.g., that the initiator is brainy) whose content they express; their speech acts; and any strict dependencies that they might have. Speech-act mark-up, in particular, works to specify what type of line may precede a given line (e.g., a line with the speech act *affirmative answer* should be preceded by a line with the speech act *yes-no question*) or succeed it (e.g., a *yes-no question* should be followed by an *affirmative answer* or other appropriate response) according to a policy we call *speech act concordance*, described in the next section.

Our annotation scheme includes tagsets for social-exchange identities, social-exchange outcomes, and instantiation preconditions that are coextensive, respectively, with *Prom Week*'s 39 social exchanges, 78 possible exchange−outcome combinations, and 447 unique preconditions that are used across all instantiations. Our speech-act tagset, which includes 35 acts and is available upon request, began as a combination of two existing tagsets [8, 1] and was refined and expanded as needed during the early stages of annotation. Additionally, we treat core social-exchange acts, such as lines of dialogue constituting a character asking another character out, as special-case speech acts, as well as lines constituting either the responder accepting or rejecting a social exchange.

While knowing a line's speech acts is typically enough to specify which lines may precede or succeed it (assuming those lines' speech acts are also known), some lines have more nuanced dependencies that must also be captured during annotation. Most often, this occurs when a line has a speech act that allows for multiple different speech acts that a preceding line may have, but due to some nuance of the line it depends on its preceding line having one specific speech act. For these cases, our scheme allows for an annotator to specify that, in any new context, a line must be preceded by a line with a certain specified speech act. In other cases, some nuance may make it so that a line cannot reasonably be used in a new context unless it is also preceded there by a specific line from its native context. This is generally due to anaphora or wordplay, and in these cases we rely on a fallback option of annotating a line as having a strict dependence on the pertinent preceding line.

For the annotation task, we use the story-encoding tool SCHEHERAZADE [5] in a way that is suited to our purposes and is not how the tool was intended to be used.[1] The actual annotation procedure works like this: An annotator is given the dialogue of an existing human-authored *Prom Week* instantiation, as well as the name of that instantiation's social exchange, its outcome, and its

[1] For a copy of our detailed annotation guidelines, please contact the first author.

n preconditions, and is tasked with annotating for which of the instantiation's line(s):

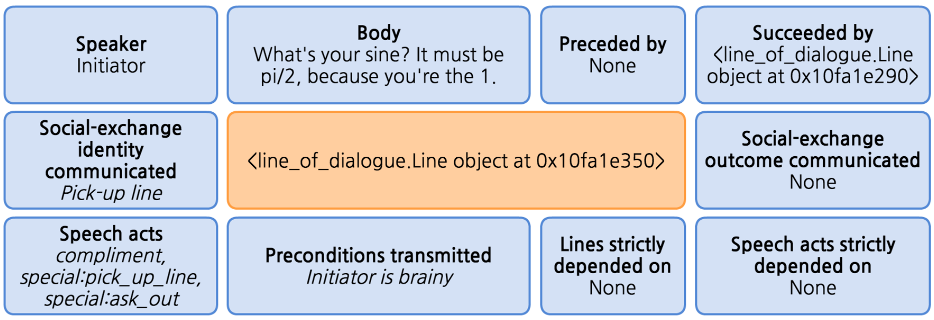
- Communicate the identity of its social exchange
- Express the content of each of its preconditions
- Communicate its outcome

Additionally, the annotator must annotate all lines for:

- Their speech acts (of which a line can have multiple)
- The speech acts they strictly depend on, if any
- The preceding lines they strictly depend on, if any

After an instantiation has been fully annotated, we use a script to process the resulting SCHEHERAZADE encoding and add each of the instantiation's lines into a database. Figure 3 shows a line of dialogue with its mark-up, which for each line also includes pointers to the lines that precede and succeed the line in its native context. This database of annotated instantiations is then queried by our combinatorial authoring procedure, which builds recombinant instantiations by reasoning about individual lines of dialogue in terms of what is specified about them by their mark-up. We describe this procedure in the following section.

Fig. 3. A line of dialogue and its mark-up.



3 Combinatorial Procedure

We generate recombinant instantiations by a combinatorial procedure that searches over the space of possible dialogue configurations, given a database of annotated lines of dialogue and a set of authoring constraints. These constraints—which comprise a targeted social exchange, exchange outcome, and set of preconditions—spell out what the recombinant exchange must *do* or *show*. Specifically, they govern the combinatorial procedure such that the recombinant instantiation must:

1. **Communicate the identity of the targeted social exchange.** Show that, e.g., a *Pick-up line* exchange is being enacted.

2. **Express the content of the targeted preconditions.** Show that, e.g., the initiator is brainy and that the responder and initiator used to date.
3. **Communicate the targeted social-exchange outcome.** Show that the responder, e.g., rejects the social exchange.

After first assembling all lines of dialogue in the database that serve to satisfy one or more of these constraints, our procedure constructs a directed search graph whose levels have nodes, respectively, for exchange-identity lines, precondition-expression lines, and exchange-outcome lines. The search then traverses this graph in a depth-first manner, incrementally building up a working instantiation as it does so. As the procedure visits a new node in the graph, it will attempt to bridge to the line of dialogue represented by that node from the final line of dialogue in the working instantiation.

For two lines to bridge, they must have *concordant* speech acts and all lines strictly depended on by the line being bridged to, if any, must already be included in the working instantiation. (Lines that are natively adjacent may be bridged together regardless of their speech acts or dependencies.) A speech act may have a backward-moving dependency, which specifies that only certain speech acts may precede it, or a forward-moving dependency, which specifies which speech acts can succeed it. Additionally, as explained above, some lines may have a strict backward dependence on a specific speech act. For two lines to have concordant speech acts, all these dependencies must be met. We have handcrafted a small knowledgebase that specifies which speech acts can precede or succeed others, which the authoring procedure consults in determining speech-act concordance.[2] If two lines cannot be directly bridged, the procedure will attempt to bridge them indirectly by searching over potential interstitial lines.

Additionally, beyond ensuring that the recombinant instantiation includes lines that communicate the targeted social-exchange identity and outcome and express the content of each of the targeted preconditions, the procedure will make sure that its first line can open the instantiation and that its final line can close it. Ideal opening and closing lines natively open and close instantiations. Otherwise, it is suitable for a line without a backward-dependent speech act to open an instantiation and for a line without a forward-dependent speech act to close one. If the working instantiation lacks these, the procedure will search for suitable opening and closing lines, as needed, and prepend or append them to the working instantiation.

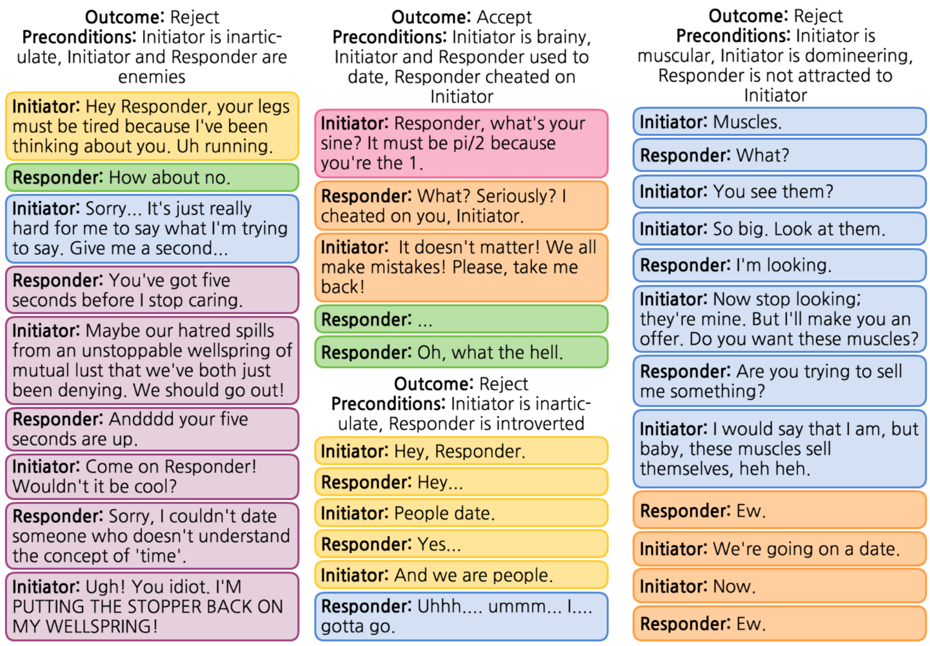
We have found that with a database of at least a few dozen annotated instantiations, the combinatorial authoring procedure can be left to randomly decide its own constraints, i.e., the targeted social exchange, outcome, and preconditions for the instantiation it will author. By doing this, authorial burden is even further reduced. In the next section, we show example recombinant instantiations that were generated in this way and describe a human evaluation experiment in which we compared human-authored instantiations to recombinant instantiations generated with random constraints and also by ablating constraints.

[2] Due to length restrictions, we cannot present this knowledgebase here. Please contact the first author for its specification file.

4 Experiment

We annotated 73 instantiations that cumulatively had 428 lines of dialogue. Believing that it would facilitate recombination, we only annotated instantiations for social exchanges with a romantic bent: *Ask out*, *Pick-up line*, *Flirt*, and *Woo*. Upon proficiency, instantiations took approximately fifteen minutes to fully annotate, of which the bulk was spent assigning speech acts. Interannotator reliability was not measured, as it is not an issue in this task—an annotation of an instantiation is essentially a reading of it, and most instantiations have multiple valid readings.

Fig. 4. Recombinant *Pick-up line* instantiations generated by our combinatorial authoring procedure. Within each instantiation, color indicates a line's native source.



Next, we wished to compare the quality of the recombinant instantiations generated by our combinatorial authoring procedure, examples of which are shown in Figure 4, to instantiations that were written by human authors. To this end, we set up a human evaluation task in which three individuals with no prior exposure to *Prom Week* were asked to rate 80 full instantiations on five criteria. The 80 instantiations were of the following types (which were not disclosed to the human raters):

- All 20 **human-authored** *Pick-up line* instantiations that currently exist in *Prom Week*.
- 20 **randomly constrained** recombinant *Pick-up line* instantiations. These were generated by allowing our combinatorial procedure to randomly select

its targeted outcome and preconditions (assuming those constraints were not represented by an existing instantiation). These 20 were generated subsequently to one another without any human moderation. As such, these best represent the general performance of our method without human intervention on its input or output—i.e., with the least authorial burden.
- 20 **unconstrained** recombinant dialogue exchanges. These constituted dialogue exchanges of proper length that were generated without any specified constraints, but with speech-act concordance still enforced.
- 20 randomly **juxtaposed** dialogue exchanges. These constituted dialogue exchanges of proper length whose lines were randomly chosen without enforcing speech-act concordance.

and the five criteria by which they were rated, on a four-point Likert scale[3], were as follows:

1. **Identity.** How well does the instantiation communicate that a *Pick-up line* social exchange is being enacted?
2. **Outcome.** How well does the instantiation communicate its specified outcome?
3. **Preconditions.** How well does the instantiation express what its targeted preconditions specify about the story world?
4. **Flow.** How well does the instantiation flow from line to line?
5. **Consistency.** How consistent are the characters in the way that they behave and speak across the entire instantiation?

Lastly, we consider an additional attribute whose value is computed directly, rather than being a subjective measure:

6. **Salience.** How much of the underlying game state does this instantiation express? *CiF* always enacts the most *salient* instantiation of the social exchange that the player selects. The more salient an instantiation is, the more preconditions it has. Because preconditions specify something about the story world, more salient instantiations have more specificity in terms of what they express about the state of the world. We determine salience by the number of preconditions an instantiation has.

Given these instantiation types and criteria, we make the following predictions:

- **H1.** Randomly constrained recombinant instantiations will not significantly differ from human-authored ones in their ratings for *identity*, *outcome*, and *preconditions.*
- **H2.** Unconstrained and juxtaposed instantiations will significantly differ in their ratings for *flow.* We predict this because only in the former is speech-act concordance enforced.

[3] 1—*Not at all well/consistent*, 2—*Not very well/consistent*, 3—*Somewhat well/consistent*, 4—*Very well/consistent.*

- **H3.** For *consistency*, randomly constrained recombinant instantiations will be rated significantly worse than human-authored ones and significantly better than unconstrained ones. We believe that targeted constraints work to partially enforce consistency, but that this is currently the biggest drop-off in quality from human-authored instantiations to recombinant ones.

5 Results and Discussion

Figure 5 shows the results of our human evaluation task. We conducted paired t-tests for the comparisons in our hypotheses, and discuss these results in terms of each hypothesis.

Fig. 5. Mean ratings on our six criteria, as applicable, for each instantiation type.

	Human-authored	**Randomly constrained**	**Unconstrained**	**Juxtaposed**
Identity	3.58	3.63	-	-
Outcome	3.7	3.2	-	-
Preconditions	3.55	3.2	-	-
Flow	3.77	3.05	2.03	1.65
Consistency	3.85	3.0	2.12	1.95
Salience	1.25	2.8	-	-

H1. We predicted that randomly constrained recombinant instantiations would not significantly differ from human-authored ones in their ratings for *identity*, *outcome*, and *preconditions*. This was true for *identity* ($t(59) = 0.37$, $p = 0.71$), but not for *outcome* ($t(59) = 3.09$, $p = 0.003$) or *preconditions* ($t(59) = 2.84$, $p = 0.006$). We account for the difference in *outcome* in the following way. Social-exchange-outcome lines often rely on context to effectively communicate outcome. For example, a responder line *Okay* clearly communicates an *accept* outcome if it follows an initiator line *Do you want to go out?*, but would communicate no outcome at all if elsewhere it were preceded by the line *Give me a minute*. By our current method, lines that are annotated as clearly communicating an outcome in their native contexts are considered by our combinatorial authoring procedure to inherently communicate that outcome, regardless of context. In light of this result, we intend for a future revision of our annotation scheme, likely in the guise of an authoring tool, to allow for richer specification of context dependence for exchange-outcome lines.

As for the difference in *preconditions*, the randomly constrained recombinant instantiations, compared to the human-authored instantiations, had more than twice as many preconditions on average. Intuitively, as an instantiation takes on more preconditions, the strength with which the total content of all its preconditions is expressed will decrease. The question then arises of whether this drop-off in precondition-expression strength is worth the increase in salience. We believe that, barring an extreme drop-off, it is, because salience is tremendously important. Instantiations with greater salience better express the aspects of game state that caused the enacted social exchange to be available to the player in the first place and that determined the responder's decision of whether to accept or reject the exchange. Even if they are not expressing the total content of their preconditions quite as strongly, recombinant instantiations are doing so for *more than twice as many preconditions*, and so the strength with which they express game state is indisputably greater.

H2. Our prediction that unconstrained and juxtaposed instantiations would significantly differ in their ratings for *flow* was corroborated ($t(59) = 2.52$, $p = 0.015$). Only in the former type of instantiation was speech-act concordance enforced, and so we take this as evidence for the utility of such enforcement in maintaining line-to-line flow across lines from different native contexts that appear adjacently in recombinant dialogue exchanges.

Beyond the comparison in this hypothesis, we find that ratings for *flow* increased substantially from unconstrained to constrained recombinant instantiations, and then again between the latter and human-authored instantiations. As for the former increase, we suspect that, while speech-act concordance works as a bottom-up moderator of line flow, targeted constraints are effective as top-down flow moderators. They restrict the dialogue exchange to a purpose, prescribed by the exchange-identity line, and a trajectory, which approaches the exchange-outcome line, and these could reasonably be expected to govern line-to-line transitioning. As for the increase in *flow* from constrained recombinant instantiations to human-authored ones, it would appear that something is needed beyond speech-act concordance and targeted constraints. We have not yet given thorough investigation to this disparity.

H3. The results substantiate both of our predictions here: In terms of their ratings for *consistency*, randomly constrained recombinant instantiations are significantly worse than human-authored ones ($t(59) = 7.18$, $p < 0.0001$) and significantly better than unconstrained ones ($t(59) = 5.87$, $p < 0.0001$). As for the latter comparison, we contend that targeted constraints could reasonably be expected to maintain character consistency for the same reasons that we have given for how it could govern line flow. Again, we find that human-authored instantiations are rated much more highly on this criterion than are constrained recombinant instantiations. In this case, however, we expected as much.

While our combinatorial authoring procedure has a policy for maintaining line flow—speech-act concordance—it has no policy by which it can enforce that characters be consistent in the way they behave and speak across an instantiation. When our recombinant instantiations are authored badly, it is usually because the responder shows a volatile temperament that is not warranted by context or any specified aspect of the story world. Typically this manifests as the responder initially appearing extremely receptive, or extremely unreceptive, to an initiator's advances, before suddenly acting in the opposite way. We will address consistency maintenance in a future revision of our annotation scheme, but description of our planned policy for it is beyond the scope of this paper.

6 Conclusion

We have developed an annotation scheme and combinatorial authoring procedure by which a small base of annotated human-authored dialogue exchanges can be exploited to automatically generate manifold new recombinant exchanges. While our recombinant exchanges were generally not rated as highly as human-authored ones, they have more than double the salience, and thus better express game state. Further, we believe that the flaws that recombinant exchanges do show could easily be repaired by a human author in far less time than it would take to author an exchange from scratch. Indeed, we envision immediate practical use of combinatorial dialogue authoring in a collaborative authoring scheme in which, given a small database of annotated dialogue, the computer instantly generates full exchanges that the human author then polishes for any small nuances that are lost on the computer. This would represent an immediate and huge reduction in authorial burden relative to current authoring practice.

One criticism of our method may be that the time it takes to author and then annotate a dialogue exchange could have been spent authoring two exchanges. This is correct and would be valid except that an annotated dialogue exchange, given at least a handful of other annotated exchanges, yields many more than two recombinant instantiations (see Figure 2). We assert that authorial leverage, on a per-line-authored basis, is greatly increased by combinatorial dialogue authoring, and we plan to test this claim in subsequent work.

The method we present here has been demonstrated using dialogue that was written for a specific game built using a specific AI system, but it can be of immediate practical use to any system that uses dialogue to express underlying state. Systems for which dialogue exchanges have a directed purpose and specify a resulting change to system state, as with the social exchange and its outcome in *CiF* games, would prove especially fertile for our implementation of combinatorial dialogue authoring.

As an immediate next step in this work, we have begun to develop an authoring tool for recombinable dialogue, in which dialogue mark-up is specified *as the dialogue is written*. In this paper, we have demonstrated the promise of combinatorial dialogue authoring as a technique that alleviates authorial burden, but we have done this using dialogue that was not written with a mind toward recombinability. We look forward to investigating how authors might write dialogue differently when recombination is already intended *at the time of writing*, as this may better illuminate the true potential of combinatorial dialogue authoring.

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