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# Towards Systematic and Sustained Formative Assessment of Causal Explanations in Oral Interactions

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**Abstract**
The questions and answers in the above exchanges are common occurrences in classroom discourse: requests by the teacher for causal explanations and efforts by the students to give them. To succeed in school, students need to be able to explain causally, and teachers need to be able to assess these explanations. Students' causal explanations allow teachers to check understandings of how and why; thus, examining the development of this type of discourse has the potential to provide a framework for formative assessment that can promote learning. Researchers and educators working from a systemic functional linguistic perspective have provided a body of work on causal discourse in science, offering an excellent starting point for examining the development of causal explanations in that subject area. Much of the work that has been undertaken has generally focused on texts written by expert writers (e.g., Mohan et al., 2002 ; Veel, 1997), such as textbooks and encyclopedias.

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**Comments**
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*Chapter 13*

# Towards Systematic and Sustained Formative Assessment of Causal Explanations in Oral Interactions

TAMMY SLATER and BERNARD MOHAN

Student: They aren't stick. They aren't stick.
Teacher: Why?
Student: Maybe this made of something with metal. Maybe this made with something else.
Teacher: Why do you think this is attracted to the magnet?
Student: Because it's both metal. They're both metal. (Slater, 2004)

The questions and answers in the above exchanges are common occurrences in classroom discourse: requests by the teacher for causal explanations and efforts by the students to give them. To succeed in school, students need to be able to explain causally, and teachers need to be able to assess these explanations. Students' causal explanations allow teachers to check understandings of how and why; thus, examining the development of this type of discourse has the potential to provide a framework for formative assessment that can promote learning. Researchers and educators working from a systemic functional linguistic perspective have provided a body of work on causal discourse in science, offering an excellent starting point for examining the development of causal explanations in that subject area. Much of the work that has been undertaken has generally focused on texts written by expert writers (e.g., Mohan *et al.*, 2002 ; Veel, 1997), such as textbooks and encyclopedias.

Education has historically considered reading and writing skills to be of primary importance, and thus research into written genres has been critical in exploring the language of schooling. An examination of oral discourse development is also important because it is typically through oral interactions in the classroom that the ability to discuss cause and effect is honed. This chapter aims to show that there is a parallel between written and oral forms of causal discourse and presents a model of causal

discourse development based on the findings from studies on written texts. It uses this model to examine the linguistic features occurring in the oral causal discourse of English as a second language (ESL) and non-ESL (native-English) speakers at two grade levels (ages six/seven and fourteen/fifteen). The point of presenting the information in this chapter is to highlight the developmental path of causal language and to suggest that this path can offer a way to support validity arguments in the assessment of these types of explanations and student understanding of causal concepts. The model outlined here is thus a basis for sustained systematic formative assessment that can contribute to our understanding of the development of both oral and written explanation. More generally, this chapter, like Mohan, Leung and Slater (Chapter 11, this volume), contributes to domain definition in the validity argument through domain analysis (Chapelle *et al.,* 2008). However, while Chapter 11 works at the broader level, such as meaning and wording in text, this chapter concentrates specifically on the discourse of causal explanations and its development, researching 'the nature of knowledge in [the relevant] arena, how people acquire it and how they use it' (Mislevy *et al.,* 2003:18).

## What is Meant by Causal Discourse Development?

A concrete example of the type of development this chapter is addressing can be illustrated by using two examples from Gibbons (1998):

> Text 1: Our experiment was to find out what a magnet attracted. We discovered that a magnet attracts some kinds of metal. It attracted the iron filings, but not the pin. It also did not attract things that were not metal.
>
> Text 2: A magnet is a piece of metal which is surrounded by an invisible field of force which affects any magnetic material within it. It is able to pick up, or attract, a piece of steel or iron because its magnetic field flows into the magnet, turning it into a temporary magnet. Magnetic attraction occurs only between ferrous materials.

The first explanation, offered as a written text by an English language learner (ELL) after doing experiments with magnets, is very much a recount of what was done and observed. The focal point of this explanation is the generalization 'a magnet attracts some kinds of metals'. The second text, written by a textbook author, contains various linguistic features that characterize it as a much more sophisticated

causal explanation, features such as nominalizations (e.g. attraction) and causal processes (e.g. affects).

A similar developmental progression occurs in oral explanations, as the data from Slater (2004) show. Bob is a seven-year-old native English speaker trying to explain how he knows there is an invisible force acting on magnets.

> Bob: Because um… there even when you can't see it you could somehow you could put it between the magnets and there's a kind of you know it feels kind of real? But another way to prove it is that… you could take another uh thing the magnet will attract to and will be attracted… and then and it would be hard to to like explain… if there wasn't one… like I mean an invisible thing.

Bob used temporal and causal conjunctions to construct his explanation, which became circular and rather confusing in his effort to say what he has understood about magnetism. In contrast, Edward is a fifteen-year-old student who has demonstrated in his class work a good grasp of science language and content. He offered his recount of the experiment his teacher did and attempted to explain his understanding of a precipitation reaction.

> Edward: When he mixed them… it turned into a yellow substance and he called—he told us that um… when something changes color and produces some sort of powder that's called a precipitation reaction? And it's not gas producing. It's just that… it just produces a solid?

Edward's oral text includes nominalizations (e.g. precipitation) and causal processes (e.g. produce) along with conjunctions, just as the more sophisticated written text did.

## The Developmental Path of Cause in Written Texts

In both the written examples from Gibbons (1998) and the oral examples from Slater (2004), a difference with regard to the stages of development can be seen. There are similar issues in language development that can be explored by examining the language features involved.

The proposed model is a schematized developmental path that moves out from the lower left corner, as shown in Figure 13.1. The vertical axis of this model suggests that there is a semantic shift moving from time to external cause to internal cause, or proof. This semantic shift draws upon Veel's idealized knowledge path and his movement from *doing* science to

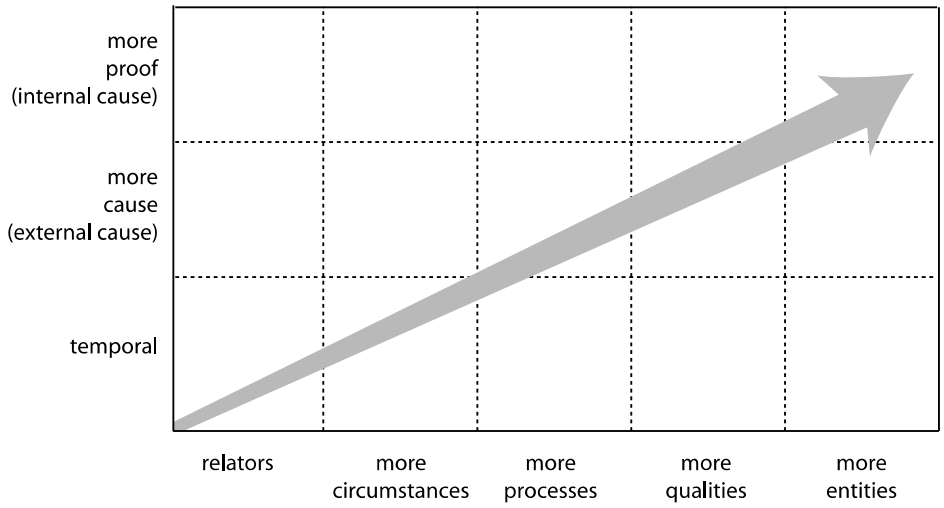


Figure 13.1 The developmental path of cause (Mohan *et al.,* 2002)

*challenging* science. The horizontal axis of the model suggests that there is also a move away from relators (conjunctions) as the primary marker of causality towards more grammatically metaphoric constructions, such as circumstances, processes, qualities, and entities, following Halliday (1998:211), who described this progression as 'the "general drift" of grammatical metaphor', from the clause complex, through to clause, and finally to nominal group, the most metaphoric construction.

As noted earlier, Veel (1997) argued that explanations for younger students tend to be sequential accounts of observable events, and it is only when the student can deal with more abstract or theoretical concepts that the explanations progress beyond the language of sequence. He proposed that there are four linguistic indicators that mark the development of content and move students from the younger, sequential explanations towards 'the abstract, technical and 'transcendental' kinds of meaning we expect of adult, educated discourse' (Veel, 1997:188). He illustrated the indicators with supporting examples from textbooks, showing that as the curriculum progresses, there are changes in the frequency of key linguistic features. These four indicators were an increase in lexical density, a higher number of nominalizations and abstractions, a shift from temporal to causal conjunctions and a move from external to internal text organization.

Veel provided a clear set of hypotheses surrounding conjunctions, lexical density and nominalizations. His basic hypotheses, based on his analysis of four explanations that progressed from the relatively visible

world of sequential observations (texts 1 and 2) to the more abstract factorial and theoretical explanations (texts 3 and 4), were:

- Lexical density will increase: For example, in text 1, Veel offered data that showed nine lexical items over three clauses (e.g. sugar, cane, comes, farms), suggesting low lexical density. He contrasted this with text 4, which contained twelve lexical items over two clauses (e.g. density, fluid, greater, average), a noticeably greater lexical density.
- The number of nominalizations and abstractions will increase: Using the same two sections of data as above, Veel showed no nominalizations or abstractions in the three clauses of text 1, but four nominalizations over the two clauses of text 4 (e.g. density, weight).
- Temporal conjunctions will decrease: Text 1 contained temporal conjunctions such as 'as' and 'then' in greater numbers than did text 4.
- Consequential conjunctions will increase: Text 4 contained consequential conjunctions such as 'if', 'because', and 'therefore' in greater numbers than did text 1.
- External conjunctions will decrease: Text 1 connected more to the observable world, using conjunctions that reflected visible sequences, such as 'as the sugar cane comes from the farms, it is washed….'
- Internal conjunctions will increase: Rather than following a natural sequence of events, the latter examples (texts 3 and 4) made more use of internal conjunctions such as 'firstly', 'secondly', and 'thirdly' to organize the text.

To explore Veel's hypotheses more fully and to elaborate on the role grammatical metaphor may play in the knowledge path, Mohan *et al.* (2002) used a computer concordancing application combined with hand analysis to examine random discourse samples of 70,000 to 75,000 words each from a science encyclopedia for learners aged eight to fourteen and from one targeted for older, university-level students. The features for analysis were taken from lists of causal items provided by previous concordancing studies (e.g. Fang & Kennedy, 1992; Flowerdew, 1998). When Mohan *et al.* tallied their findings from the corpus analysis and held them up against Veel's hypotheses, they found a mixed pattern of results. There was support for the first three hypotheses but not for the last three.

Mohan *et al.* went on to track the frequencies of various processes, qualities, and entities in the two encyclopedias as well. They discovered that whereas the number of external causal processes dipped slightly in the encyclopedia for older students, the number of proof processes

(internal cause) increased. The findings appeared to suggest that causal language develops along two dimensions: a semantic dimension and a lexicogrammatical dimension, as the model in Figure 13.1 captures. Semantically, the numbers suggested that there is a move from time, through cause, to proof. Lexicogrammatically, there is a shift away from the use of conjunctions to more metaphoric ways of constructing meaning. This developmental pattern offers important evidence to support the validity of judgments that rate one performance of causal discourse over another.

## The Development of Oral Causal Discourse

To use the information captured in this 'developmental path of cause' in formative assessment, it needs to be seen whether learners' oral explanations follow similar paths to what was found in the texts written by experts. In Slater (2004), native English-speaking students from the primary grades (ages six/seven) and high school (ages fourteen/fifteen) as well as non-native English-speaking students at the same age levels were asked to explain their knowledge of what they had been studying in their science classes. Ten hours of interviews were recorded, transcribed, and analyzed with the same concordancing techniques as used in Mohan *et al.* to see if the results would pattern out in similar ways. In the following paragraphs, trends between the native English speakers in the primary and the high school grades as well as those between ESL and native English speakers will be discussed.

When the interviews from the native English speakers in the primary and high school grades were examined, a similar pattern emerged to that of the Mohan *et al.* data. As Table 13.1 suggests, the developmental move appeared to be both *semantic*, from time to cause to proof, and *grammatical*, from less to more metaphoric. There was a visible shift in the direction of grammatically metaphorical constructions as well as a shift towards causal features as the constructions became more metaphorical. Causal and temporal processes were used more in the older grades, as were participants and metaphoric entities in general. The largest increase in the metaphorical entities occurred with processes and with nominalized qualities, suggesting that the older students have a higher level of ability to manipulate the lexicogrammar than do the younger students. Halliday (1993) stated that this ability to handle grammatical metaphor begins at about grade eight, and although this research cannot verify that claim, it does support the idea that this ability develops at some point between grades two and nine.

**Table 13.1** The native English speakers (Slater, 2004)

| ***Linguistic feature*** | ***Primary*** | ***High school*** |
|---|---|---|
| External temporal conjunctions | 25.35 | 51.11 |
| External causal conjunctions | 29.11 | 12.81 |
| Internal conjunctions | 0 | .28 |
| Temporal circumstances | 15.96 | 22.56 |
| Causal circumstances | 3.76 | .56 |
| Temporal processes | 0 | 1.39 |
| Causal processes | 1.88 | 6.41 |
| Proof processes | .94 | .7 |
| Temporal entities | 0 | 2.51 |
| Causal entities | .94 | 4.46 |
| General metaphoric entities | 0 | 16.99 |

*Note:* Numbers have been normalized to occurrences in 1000 words

The following discourse examples[1] will attempt to illustrate both the grammatical and semantic differences between the younger students and those in high school. The teacher who was doing the interviews in the primary class asked Bob to offer proof that an invisible force exists, that of magnetism. With regards to the lexicogrammar, Bob mainly used conjunctions to construct the argument, as highlighted in bold. He used one process of proof, in the word "prove." The ellipses signify short pauses in his speech, reflecting time needed to think. With regards to semantics, the younger students had difficulty talking about internal cause, specifically with offering proof texts, as this analysis of the example provided above attempts to show.

> Teacher: So how do you know that there is an invisible force? Bob?
> Bob: **Because** um… there even **when** you can't see it you could somehow you could put it between the magnets and there's a kind of you know it feels kind of real? But another way to ***prove*** it is that… you could take another uh thing the magnet will attract to and will be attracted… **and then** and it would be hard to to like explain… **if** there wasn't one… like I mean an invisible thing.

Bob's explanation for how to prove the existence of magnetism is unclear. He suggested that it 'feels kind of real' and that it would be hard to explain attraction if there wasn't 'an invisible thing' there. In general, when the native English speaking primary students were asked about proof, their arguments became quite circular, as the above attempt shows.

By contrast, the high school native English speakers were quite eloquent constructing internal proof, and their ability to use more grammatically metaphorical constructions was much greater, as the following example exemplifies. Sara and Jeanie recounted the experiment they had recently witnessed, using a temporal conjunction in the last sentence of this recount. They used several metaphorical entities (underlined) as well as a process of proof, 'proved' (bold italics), thus making their explanation more grammatically metaphoric than what Bob had offered.

| | |
|---|---|
| Sara: | **And then** we weighed it again and it was exactly the same to the hundredth of a gram. |
| Researcher: | And what does that show? |
| Sara: | That… |
| Jeanie: | The mass of the <u>reactants</u> is the same as the mass of the <u>products</u>. |
| | [Which is |
| Sara: | [That's the law of the <u>conservation</u> [of mass. |
| Jeanie: | [Of mass. |
| Researcher: | Mm-hmm? |
| Sara: | So we ***proved*** it. |

These students explained that they were able to prove the scientific law they were studying by carrying out an experiment and applying their findings. In other words, even though both groups of students talked about proof, the older students were able to handle the concept much more logically and convincingly in their explanations, and used more grammatically metaphoric language to do so.

The data from the native English speakers and the ELLs at the primary grades were consistent with the lower end of the model. The students appeared to be dependent on conjunctions for constructing causality, and both temporal and causal conjunctions were used, depending on the question prompts they heard. There were minimal numbers of causal entities or processes, supporting Halliday's suggestion that grammatical metaphor is not a characteristic of young children's discourse. But whereas one might expect that native English speakers would perform

better linguistically than ELLs, no marked differences were found. A possible explanation surfaced from a qualitative study of the ELL classroom. It appeared that the ESL teacher had undertaken a systematic approach to integrating language and content for the students, very carefully building up the meaning and wording of the subject matter and taking considerable care to review orally the material with the students on a regular basis. [For a full description of this research, see Mohan and Slater (2005)].

At the high school level, the data are more revealing, showing aspects of causal discourse development that are of particular importance with regards to formative assessment of ESL students at this level. A path similar to the one Mohan *et al.* suggested appeared when the interviews from the high school ESL speakers and the native English speakers were examined. As Table 13.2 shows, this path was much like the one that was constructed when the interviews from the primary and high school students were explored, with one exception. The high school ESL students used more temporal circumstances than did the native English speakers, but given that one of the tasks in the interview was to explain the changes in the state of water throughout the four seasons, the

**Table 13.2** The high school speakers (Slater, 2004)

| ***Linguistic feature*** | ***ESL*** | ***Non-ESL*** |
|---|---|---|
| External temporal conjunctions | 29.68 | 51.11 |
| External causal conjunctions | 30.53 | 12.81 |
| Internal conjunctions | 0 | .28 |
| Temporal circumstances | 30.31 | 22.56 |
| Causal circumstances | 1.47 | .56 |
| Temporal processes | 0 | 1.39 |
| Causal processes | 4.21 | 6.41 |
| Proof processes | 0 | .7 |
| Temporal entities | 0 | 2.51 |
| Causal entities | 0 | 4.46 |
| General metaphoric entities | 11.37 | 16.99 |

Note: Numbers have been normalized to occurrences in 1000 words

higher number of temporal circumstances is natural, boosted by phrases such as *in summer* and *in winter*.

As noted earlier, the native English speakers at this level were able to use grammatically metaphoric constructions with relative ease. Edward, for example, was able to move from the more congruent form of a recount using temporal conjunctions (bold) into a generalized statement that included the nominalization of a scientific process (underlined), then move back down through qualities (italics) to the more congruent form, using a causal process (bold italics):

> Edward: **When** he mixed them… it turned into a yellow substance and He called—he told us that um… **when** something changes color and produces some sort of powder that's called a precipitation reaction? And it's not *gas producing*. It's just that… it just ***produces*** a solid?

Sara showed her ability with grammatical metaphor by using it in a very colloquial manner. Her nominalization of a process captured her confusion about the adjustments needed to make a clean flame in a Bunsen burner:

> Sara: And I totally didn't get the whole… gas down here and gas up here thing.

This ability to be creative with the language was not evident in the discourse of the ESL students. Moreover, students such as Edward, Sara and Jeanie were able to make the necessary changes to a word so that it fits logically into the grammatical structure they have chosen to use. The following three examples show how they are able to manipulate the lexicogrammar easily, moving from appropriate processes to entities.

> Sara: So we did this experiment… to observe some substances and how they *reacted* with each other.
>
> Sara: So the point of our experiment was to judge whether or not… um… a *reaction* occurred between substances.
>
> Jeanie: When we weighed the product it was less than the *reactants*.

In contrast, not only were the ESL students not using the more grammatically metaphoric features as often as the non-ESL students, as shown in Table 13.2, but when they attempted to use them, they frequently had difficulties. They often used a single term to cover the same concept in a variety of constructions, as the following two examples show.

Belinda: When they join together they will have *reactive*.

Vicki: They… they'll *reactive*. I mean the element is easy to join. It's easy. Of course some elements not join… not *reactive*.

The ESL students had trouble with explanations because they did not appear to have the depth of language resources that the mainstream students had for constructing them. They relied more on conjunctions and circumstances than did their native English-speaking peers, they struggled for the correct lexis, and they took much longer to respond. Moreover, when they attempted more grammatically metaphoric constructions, they often had difficulty and aborted their efforts in favor of more congruent and familiar language. The following excerpt clearly illustrates this.

Keifer: Then with we nitro so then then we saw a when it got hot water inside… like (xx) element and (xx) water. But go inside and *(makes a whooshing sound).*

Ken: Explodes.

Keifer: Explode. Yeah. Explode.

Tony: Yeah. That means it's very reactive.

*(A few turns later.)*

Tony: And sometimes some elements don't react don't act don't react with uh… water or… or air or something else.

Ken: Yeah. But some elements like iron? If you if you have water and put iron into water it will get run rust. It's un that's uh… *(17 seconds pass).* Uh… *(2 seconds pass).* Not reactive. *(6 seconds pass).* Not reactive with… it's like uh iron… iron. Put it into water oh no not iron. Not not reactive with uh element. Put it into water and **it doesn't make… isn't… it doesn't explode.**

Keifer: Yeah.

Ken: It's not reactive.

What is especially interesting in this excerpt is Ken's attempt to use a highly metaphoric, causal construction. The causal process *make* requires an entity after it ('make an explosion'), and Ken was unable to supply one. He aborted this and instead came down one level in Halliday's drift of grammatical metaphor by attempting to construct a phrase requiring a quality ('isn't explosive'), but was unable to complete that phrase as well. Finally, he finished his thoughts by using the negative of the process he had used earlier with confidence ('doesn't explode'). In other words, Ken appeared to have aimed for the higher 'entity' end of the lexicogrammar, but had to fall back to the process he was more familiar with.

## Assessing Causal Explanations in the Teaching and Learning Cycle

The aborted attempts at using more grammatically metaphoric constructions, such as the attempts described above, offer excellent opportunities for using formative assessment in the teaching and learning cycle. In making an unsuccessful effort, the students can perhaps be considered to be in Vygotsky's Zone of Proximal Development (Vygotsky, 1978), where guidance and support of the expert (teacher) is needed to scaffold their development of new concepts and language. Mohan and Beckett (2003:431) suggested that the scaffolding of ESL students through the teacher's functional recasts forms 'a "zone of negotiation" for reworking and reconstructing the text that [the student] is developing, as [the student] practices presenting causal explanations'. Within a classroom situation, a teacher who notices the difficulties that students are having with grammatical metaphor can open up this zone, leading to a potential *assessment-to-teaching/learning cycle*, which is a primary goal of formative assessment.

Students need to be able to explain their understandings of cause and effect in order to further their content knowledge, because their teachers often attempt to build on what they hear their students saying. Students also need to be learn how their linguistic choices reflect their developing understanding of the topics they are studying, rather than simply learning correct grammatical forms. Functional recasting to help students learn how to construct more sophisticated oral causal explanations, as described in Mohan and Beckett (2003), is a useful strategy that depends on teachers being able to assess quickly and scaffold the student so that learning occurs within the zone of negotiation. Slater *et al.* (2006), in their paper on assessing projects as second language and content learning, go beyond teacher recasts by offering ways to raise *student* consciousness of the features of sophisticated causal explanations, emphasizing for them the importance of what is happening on this developmental path (see also Beckett & Slater, 2005). If teachers are consistently and reflectively assessing student explanations, focusing on aspects that students are having trouble with, they can provide successful assessment-learning cycles for teaching the forms and meanings of causal explanations. The developmental path of cause suggested in this chapter offers teachers a way to do this assessment and teaching.

This chapter has used data from both native English speakers and ELLs from primary school and high school to expore oral causal language development. The findings suggest that there appears to be a

general path of development for oral causal meanings, just as with written discourse, which moves semantically from time to cause to proof, and lexicogrammatically from conjunctions through circumstances, processes, qualities, to entities. The existence of this path provides a way to support validity arguments, as it offers important evidence to support the judgments that rate one performance of a causal explanation over another. Younger students, who focus on more on *doing* science and depend mostly on conjunctions to construct their causal explanations, appear to be farther behind on the developmental path than older students, who are adept at manipulating the lexicogrammar and the semantics to explain their understandings of cause and effect. But it is the findings from the high school ESL students that have particular importance for the discussion of assessment. Not only do these students appear to be farther behind than their English-speaking peers on the developmental path of cause, there is evidence that they are struggling to construct the more grammatically metaphoric constructions that are typical of advanced causal explanations and a key part of higher-level literacy. Understanding this developmental path of cause allows teachers to create a formative assessment-for-learning cycle, which in turn helps to promote successful language-and-content learning. At a broader level, this model has important implications for judging validity in standardized written tests as well as academic oral proficiency interviews, neither of which has yet approached academic language assessment from such a perspective.

## Note

1. All further discourse examples unless noted are from Slater (2004).

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