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"God is in the Details": The Effect of Directional Verbs in Process Explanations on Text Coherence

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Keywords: *causation, causal explanations, causal mechanism, text coherence, persuasion, causal beliefs.*

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"God is in the Details": The Effect of Directional Verbs in Process Explanations on Text Coherence

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Abstract- This research focuses on the verbs in causal explanations, and shows how they convey previous causal knowledge to produce coherent texts. In three studies, we manipulated the degree of text coherence by changing the verbs' direction of influence to be consistent with previous knowledge (e.g., a food additive that claims to produce weight loss by *reducing* appetite), inconsistent with previous knowledge (e.g., by *inducing* appetite), or unspecified (e.g., by *affecting* appetite). We demonstrate that for short chains (one mediator), because people tend to complete the direction spontaneously, the unspecified and the coherent conditions did not differ when both yielded better understanding and higher persuasiveness and reading fluency than the incoherent condition. For longer chains, because spontaneously completing the direction of influence is almost impossible, the unspecified condition was as bad as the incoherent condition when the coherent condition yielded better understanding and higher persuasiveness and reading fluency than both. Process analysis demonstrates people are sensitive to directional verbs because they convey previous causal knowledge that facilitates the accommodation of the novel information to previous beliefs.

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I. Introduction

In marketing communication consumers are often exposed to causal claims stating a certain cause (e.g., a new bubble bandage) produces a certain effect (e.g., heal cuts faster). To foster causal-claims acceptance, marketers often recruit explanations of the process (mechanism or causal chain) by which the cause produces the effect (Fernbach, Sloman, Louis & Shube, 2013; Kuhn, 2001; Lombrozo, 2006). For example, to foster acceptance of the claim that the new bubble bandage heals cuts faster, the packaging might explain, "The bubbles *decrease* contact of the bandage with the wound, which *increases* air and oxygen circulation around it. Oxygen in the air *kills* many bacteria, causing the wound to heal faster." Studies show process explanations enhance the probability of the causal-claim acceptance (Anderson 1980; Koehler, 1991; Ross, Lepper, Strack, & Steinmetz, 1977; Walsh & Sloman, 2011), foster conceptual coherence (Murphy & Medin, 1985; Patalano, Chin-Parker & Ross 2006), and are accompanied by a sense of understanding (Ahn, Novick, & Kim, 2003). These effects result mainly because explanations use previous causal knowledge on the mechanism by which the cause produces the effect that enables accommodation of the novel information to those beliefs (Kalish, Medin, & Gelman., 1995; Lombrozo, 2006).

Previous considerations on the nature of the mechanism emphasize its being content-specific (Ahn et al., 1995), and focus on the entities (variables) that constitute the explanation (e.g., bubbles, wound, and air) and the links that exist between them (Einhorn & Hogarth, 1986). Yet, a crucial part of any explanation, which enables accommodation of the novel information to previous knowledge, is that the link between any variable in the chain to its follower is of a certain *direction*. Consider, for example, the sense of understanding if the verbs (in italics) in the explanation on the bubble bandage were changed such that they do not specify the direction of influence: "The bubbles *influence* contact of the bandage with the wound, which *affects* air and oxygen circulation around it. Oxygen in the air *affects* many bacteria, causing the wound to heal faster." This example illustrates the vital role of verbs, which indicate the direction of influence (hereafter directional verbs) from one entity (variable) to the next, in one's understanding of an explanation. In fact, in a pilot study, 30 students read one of the two versions specified above. Results showed that sense of understanding was higher among the students who read the first version (in which the direction of influence is specified) than among the students who read the second version.

The purpose of the present study is to demonstrate that while processing causal explanations, reasoners are sensitive to the information provided by the direction of influence. Specifically, we assert that specifying directional verbs that fit with previous knowledge makes the explanation coherent and thus fosters understanding, causal-claim acceptance (belief in the causal claim, understanding and higher persuasiveness (belief in the causal claim, willingness to perches the product, product's perceived efficacy), and reading fluency. In fact, satisfaction, which Gopnik

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(2000) found accompanies sense of understanding, signifies to the reasoner that the explanation "sits well" with previous knowledge.

We organize the article as follows: First, we discuss and review studies demonstrating the central role explanations plays in our cognition. We also review studies showing previous causal knowledge constitutes an important part of explanations. Then we clarify how previous knowledge is expressed in mechanism explanations, by focusing on its structure. We review studies that demonstrate the importance of verbs in representing causal narrative texts, and discuss the importance of directional verbs in establishing text coherence. Finally, we present our hypotheses and three studies that tested them, and discuss the implications of the results.

II. Explanations and Cognition

Explanations play a central role in causal reasoning. People appear to depend on explanations that help make sense of causal claims (Kuhn, 2001). Specifically, when confronted with an event, people ask for information on the mechanism that could explain it (Ahn et al., 1995). Similarly, when asked to justify or argue for a claim, they tend to offer explanations on the mechanism (Glassner, Weinstock, & Neuman, 2005; Khun, 2001).

Moreover, studies show that explanations affect judgments and inferences on the probability of causal claims. Participants judged the probability of causal claims as higher when they were asked to explain them (Ross et al, 1977; Anderson, Lepper, & Ross, 1980). Walsh and Sloman (2011) demonstrated causal attributions rely on peoples' understanding of the process involved in bringing about the outcome (the presence of a causal mechanism). Fernbach et al. (2013) demonstrate that preference for a product claiming to produce some benefit (effect) is enhanced when people are provided with some causal mechanism that explains how it works. In addition, a growing body of evidence suggests the interpretation and impact of covariation data depend on prior beliefs about the mechanism (Sloman, 2009). For example, in a seminal study, Chapman and Chapman (1969) found clinical psychologists' beliefs regarding the mechanism by which psychological disorders produce symptoms affect how data are perceived to covary (see also Fugelsang and Thompson, 2003; Slusher and Anderson, 1996). Recent studies have found the causal structures of our beliefs (e.g., a causal chain structure) affect judgments of conditional probability (Bes, Sloman, Lucas, & Raufaste, 2012), how covariationis assessed (Waldmann & Hagmayer, 2001), and the expected covariation between events (Perales, Catena, & Maldonado, 2004).

Finally, research has found that good explanations foster text readability and conceptual coherence (Cain & Nash, 2011; Murphy & Medin, 1985; Patalano et al., 2006) and are accompanied by a sense of understanding (Ahn et al., 2003) and satisfaction (Gopnik, 2000).

III. Explanations and Previous Causal Knowledge

Recently, most authors recognize the central role previous knowledge plays in causal reasoning in general (see, e.g., Lagnado, Waldmann, Hagmayer, & Sloman, 2007; Waldmann & Hagmayer, 2001) and in causal explanations in particular (Ahn et al., 1995; Einhorn & Hogarth, 1985; Lombrozo, 2006). The profound effects of explanation on our cognition might result mainly because they use previous causal knowledge that enables accommodation of the novel information to those beliefs (Ahn et al., 1995; Lombrozo, 2006).In the process of searching for an explanation for some event, only a subset which comforts previous knowledge is considered (Ahn et al., 1995; Lombrozo, 2006). Specifically, the causal attribution process is content-specific when the claim is that people know a set of mechanisms and try to figure out during the process of causal attribution whether a particular mechanism is appropriate (Ahn et al., 1995). Thus, explanations constrain causal inference by reducing the range of possibilities considered to those consistent with prior beliefs about causal mechanisms (Lombrozo, 2006). In addition, Kendeou and van den Broek (2007) found that previous knowledge affects the process in which participants are engaged while trying to understand scientific texts.

IV. Mechanistic-Explanation Definition

Previous considerations on the nature of process explanations emphasize the existence of intermediate variables that lie on a spatio-temporal contiguous path from cause to effect (Fernbach et al., 2013; Walsh and Sloman, 2011). Any causal mechanism can be described in different level of details, from very short (only one mediator variable) to very long ("micro mediation") (Einhorn & Hogarth, 1986; Walsh & Sloman, 2011). The number of intermediate variables and links (=the number of intermediate variables plus one) that lie between the cause and the effect determines the causal-chain length (Einhorn & Hogarth, 1985). Yet, this definition fails to consider a crucial property of any mechanistic explanation—the fact that the links in the chain convey information on the way in which the variables affect each other. This information is expressed by what we call *directional verbs*, which state the direction in which the preceding variable of each pair in the causal chain influences the following one.

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V. The Importance of Verbs

Studies show that causal relations in general and verbs in particular play a prominent role in the mental representation of stories (see, e.g., Fletcher, Hummel & Marsolek, 1990; Trabasso, Scott, & van den Broek, 1989; Trabasso & van den Broek, 1985; Trabasso, van den Broek & Suh, 1989). Specifically, Trabasso & colleagues (Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985; Trabasso, van den Broek, & Suh, 1989) analyzed the causal structure of several short narrative texts. The fundamental step was to represent the text as a list of clauses and the relation between them. They found verbs to be important in two crucial respects. First, the basis of parsing the clauses was that each includes one verb predicate. Moreover, they found verbs to be essential because they carry information on states and actions that result in states changes.

VI. The Importance of Directional Verbs

The studies of Trabasso and colleagues demonstrate the importance of verbs in representing causal relations and in understanding narrative texts. These verbs signify the shift a preceding variable in the chain produces on the flowing variable. To understand the entire explanation, the reasoner must check for each shift—before continuing to the next shift—if the direction of influence specified for the pair fits previous knowledge. Verbs produce coherent text when the combination of the directions of influence specified in the explanation fits previous knowledge (e.g., a yogurt that *reduces* weight by *reducing* appetite). Verbs produce incoherent text when the combination of the directions of influence specified in the explanation does not fit previous knowledge (e.g., a yogurt that *reduces* weight by *inducing* appetite).

The effect of unspecified verbs on text coherence depends on the explanation's length. For short chains (only one mediator variable), because only one completion of direction is needed to make the explanation congruent with previous knowledge, people complete it spontaneously. For example, if people are informed that a certain yogurt (C) *affects* weight loss (E) by *affecting* one's appetite (M), based on previous knowledge, they spontaneously complete the direction: *reduces* appetite. Thus, for short chains, unspecified verbs are as effective as coherent verbs. The ability to spontaneously complete the direction of influence becomes almost impossible when more than one mediator variableis present, because many possibilities exist to present the whole explanation while specifying the directions of influences. Specifically, the number of versions of an explanation that can be presented while specifying the direction of influence is the product of the number of verbs in the explanation and two directions. For example, suppose a cell phone company presents a new phone cover that claims to reduce radiation via a tiny metal mesh it contains. When the direction of influence is unspecified, we might be explained that (verbs in italic) "the metallic material *influences* the radio waves and thus *affects* their intensity which *modifies* the radiation level." Substituting the unspecified verbs with directional verbs results in six versions of the explanation that are the product of three verbs (*influences, affect, modify*) and two possible directions (*dissolute* or *consolidate; reduces* or *induces; reduces* or *induces*, respectively*).* Thus, when the directions of influence are not specified, spontaneously completing the directions to make the explanation coherent is not possible. Also, expecting the reasoner to make the effort needed to produce a coherent explanation, such as to produce the complete list of the explanation's versions (6), judge for each if it fits with previous knowledge, and finally pick the "correct" one, is unrealistic. Consequently, for chains in which more than one mediator variable exists, unspecified verbs become almost uninformative and thus incapable of conveying previous knowledge that could facilitate text comprehension. Hence, for long chains, texts in which the directional verbs are unspecifiedare as "bad" as texts in which the directional verbs are incoherent (incompatible with previous knowledge). Thus, including coherent directional verbs in explanations that contain more than one mediator is essential to achieve the positive effects mentioned.

Notice that to make the explanation incomprehensible with previous knowledge, all the verbs do not need to be unspecified or incoherent; that some of them are is enough.

VII. Text Coherence: Connectives vs. Directional Verbs

Conceptual coherence is established when the reader can relate the events in the text such that the representation captures the text meaning (Cain & Nash, 2011).

We assert that stating the directions of influence when proposing a mechanistic explanation produces a coherent text, because they signal to the reader the form of relations between the adjacent entities (variables), and thus how to integrate the information to make it comprehensible.

As far as we know, no studies have examined the positive effects of text coherence established by directional verbs. Yet, studies have examined the effects of text coherence established by connectives (or conjunction). Different authors have categorized connectives as temporal (e.g., before, after, then), causal (e.g., because, due to, therefore), adversative (e.g., but, although), and intentional (so that, in order

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that) (see, e.g., Cain & Nash, 2011; Caron, Micko, & Thuring, 1988). Studies show the presence of appropriate connectives produces a higher sense of comprehension, higher ratings of text coherence, faster reading time, better memory of the text, and easier inference making (Cain & Nash, 2011; Caron, Micko, & Thuring, 1988; Ferstl & von Cramon, 2001).

VIII. Hypotheses

To examine the positive effects (understanding, causal-claim acceptance, and reading fluency) of the explanation's coherence established by directional verbs, we provided participants with explanations of the process by which an artifact (a product) produces an effect (a benefit), while manipulating the verb's direction. In the *incoherent* condition, the direction stated does not seem sensible (e.g., a food additive that claims to produce weight loss because it contains an ingredient that "induces" appetite); in the *coherent* condition, the direction stated seems sensible (e.g., reduces appetite); and in the *unspecified* condition, the direction was not stated (e.g., "affects").

In our hypotheses, we distinguish between short chains (one mediator, two links, and two verbs) and longer chains (more than one mediator). Hypothesis 1 refers to short chains, and hypothesis 2, to long chains.

H1a: We expect no difference between the *coherent* and the *unspecified* conditions in sense of understanding, causal-claim acceptance, and reading fluency.

H1b: Sense of understanding, causal-claim acceptance, and reading fluency will be higher when the explanation is *coherent or unspecified* than when it is *incoherent*.

H2a: We expect no difference between the *unspecified* and the *incoherent* conditions in sense of understanding, causal-claim acceptance, and reading fluency.

H2b: Understanding, causal-claim acceptance, and reading fluency will be higher when the explanation is *coherent* than when it is *unspecified orincoherent*.

H3: The degree of fit of the explanation with previous knowledge mediates the effect of text coherence on sense of understanding, causal-claim acceptance, and reading fluency.

a) Overview of Studies

In three studies, participants were presented with several stories. Each story presented a product (e.g., a plant) whose description claimed to produce a benefit (e.g., prevent mosquitoes' bites), explained the mechanism that specified the way the product produced the effect (e.g.," the plant has flower buds that disperse a substance that…"), and provided the direction of influence. The direction of influence was either coherent (e.g., "…*reduces* mosquitoes alertness"), incoherent (e.g., "…*increases* mosquitoes alertness"), or unspecified (e.g., "…*affects* mosquitoes alertness"). We measured sense of understanding, causal-claim acceptance, and reading fluency. We used two items to measure understanding: personal sense of understanding and the ability to explain to others how the product works. We integrated the two questions into one measure (Cronbach's alpha > 0.80), which we call sense of understanding. To assess causal-claim acceptance, we used two indirect and thus less reactive measures: WTP (in the three studies) and product's perceived efficacy (in studies 2 and 3). We derived the product's perceived efficacy measure by asking participants to give numbers that expressed the covariation they expected between using the focal product and receiving the benefit (described in details in the method section). We also measured the fit of the explanation with previous knowledge, and how reasonable the explanation sounds (a manipulation check).

The purpose of study 1 was to test the hypotheses for short chains (one mediator). The purpose of study 2 was to test the hypotheses for long chains (several mediators). The purpose of study 3 was to refute the rival explanation that people report a greater sense of understanding for the coherent condition, not because they really understand but because they experience a higher reading fluency. Rawson and Dunlosky (2002) provide evidence that when people experience reading as fluent, they report they understand when actually they do not.

Study 1

In study 1, we show the effect of coherence established by directional verbs, for short explanations (only one mediator variable) (H1 and H3).

b) Method

i. *Participants and Design*

We presented 66undergraduates (males = 21.1%, M_{age} = 30.05; SD_{age} = 7.80) with a Qualtrics web-based questionnaire for course credit, in a within-subjects design. Each participant read four stories, one for each of the three conditions of the direction of influence (coherent, unspecified, and incoherent). We randomly assigned the stories to the conditions.

ii. *Procedure and Materials*

Each story had three versions of the direction of influence: incoherent, unspecified, and coherent. We used four stories(verbs in italic are those used in the incoherent/ unspecified/ coherent conditions, respectively): (1) a plant that prevents mosquito bites because it has flower buds that disperse a substance that *increases/affects/decreases* mosquitoes' alertness; (2) a sticker that helps one lose weight quickly because it contains an herbal extract that *slows/ affects/ accelerates* fat burning; (3)a product that prevents slipping on wet roads, because it contains a substance that *reduces/affects/increase* tire grip on the road; and

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(4) a chewing gum that enhances concentration, because it releases endogenous substances that *decrease/ affect/ increase* one's level of concentration.

iii. *Measures*

For each story, we measured the following:

a) One's sense of understanding. Participants rated their understanding on a 6-point scale (1=*do not understand at all*, 6=*completely understand*) and one's ability to explain to others the way the product works (1=*not at all*, 6=*very much*).We created a measure that was the mean of these two items (alpha Cronbach = 0.81 to 0.89), which we named sense of understanding.
b) Causal-claim acceptance. Participants rated their willingness to purchase the product, using a six-point scale (1=*definitely not*, 6=*definitely yes*).
c) Consistency of the explanation with previous knowledge. Participants rated how well the explanation fit with their previous knowledge, using a six-point scale (1=*does not fit at all*, 6=*completely fits*).
d) Explanations' reasonability (manipulation check). Participants rated the reasonability of the explanations, using a six-point scale (1=*does not make sense at all*, 6=*completely makes sense*).
e) Reading fluency. Reading time indicated reading fluency (see, e.g., Cain & Nash, 2011; Dreisbach & Fischer, 2011), and was measured automatically and used in the analyses after log transformation.
f) Spontaneous completion of the direction of influence. To check whether participants tend to spontaneously complete the direction of influence, in the unspecified condition, they were asked to choose one of three answers concerning their assumption about the direction of influence (did not assume/increase/decrease). (For the exact wording for each story, see Appendix A1).

c) Results

Table 1 and Figure 1present the means of the three experimental conditions (incoherent, unspecified, and coherent) for each of the measures: reasonability (manipulation check), understanding, willingness to buy and reading fluency (dependent variables), and fit with previous knowledge (the proposed mediator).

Table 1: Study 1: Means (and standard deviations) of the three experimental conditions (incoherent, unspecified, and coherent) in reasonability, understanding, willingness to buy, reading fluency, and fit with previous knowledge

	Manipulation check	Dependent variables			Mediator
	Reason-ability	Under-standing	Willingness to buy	Log reading time	Fit with previous knowledge
incoherent	2.97 (1.49)	3.59 (1.35)	2.83 (1.62)	1.42 (.28)	3.12 (1.59)
unspecified	3.86 (1.41)	4.01 (1.42)	3.43 (1.48)	1.35 (.26)	3.83 (1.43)
coherent	3.95 (1.18)	4.36(1.15)	3.40 (1.40)	1.32 (.35)	4.06 (1.21)

Fig.1. Study 1

Ratings as a function of direction of influence (incoherent, unspecified, and coherent) in reasonability (a), understanding (b), willingness to buy (c), reading fluency (d), and fit with previous knowledge (e).

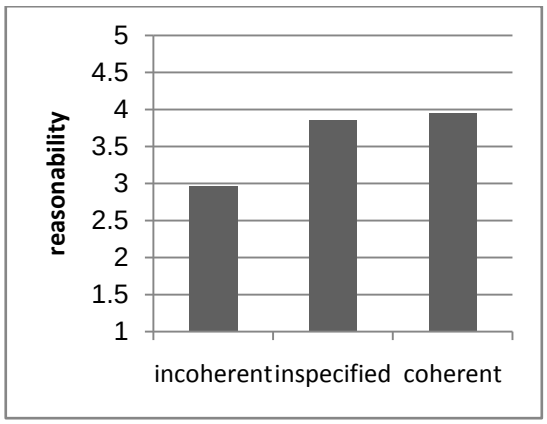

Fig. 1a: Explanation's Reasonability

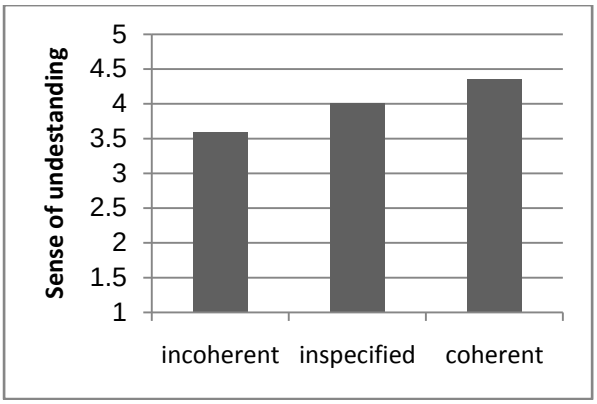

Fig. 1b: Sense of Understanding

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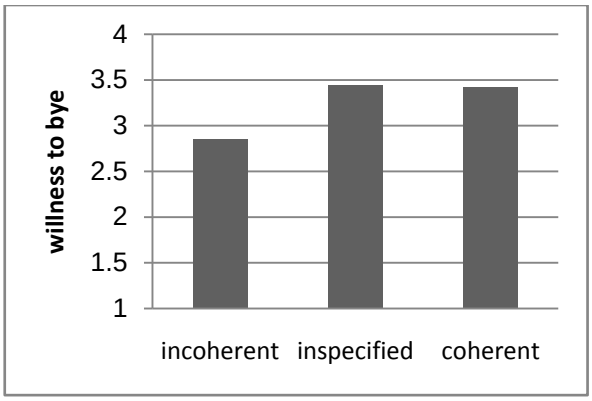

Fig. 1c: Willingness to Buy



Fig. 1d: Reading Time



Fig. 1e: Explanation's fit with previous knowledge

i. *Manipulation Check*

The effect of the direction of influence on reasonability was significant ($F(2,128) = 9.24$, $p < .001$, $\eta^2_p = .126$). As expected, on average (see alsoTable 1and Figure 1a), participants rated the explanation as equally reasonable for the coherent and the unspecified conditions ($F < 1$), when these two conditions were rated as more reasonable than the incoherent condition ($F(1,64) = 15.81$; $p < .001$; $\eta^2_p = .198$).

ii. *Spontaneous completion of the direction of influence*

As expected, in the unspecified condition, only 13.6% of participants did not assume any direction (chi square for goodness of fit = 34.91, $p < .001$). Moreover, among 86.4% of participants that assumed some direction, about 70% assumed the coherent direction (chi square for goodness of fit = 9.28, $p < .001$). It is noteworthy that although most of the participants spontaneously complete the coherent direction, as mentioned before some (13.6%) did not assumed any direction and some (10.6%) assumed a wrong direction.

H1: Effects of text's coherence on understanding, causal-claim acceptance, and reading fluency

As predicted, the direction of influence had an effect on all the measures (understanding: $F(2, 130) = 6.52$, $p < .001$, $\eta^2_p = .091$; willingness to buy: $F(2, 128) = 3.95$, $p < .05$, $\eta^2_p = .058$; log reading time: $F(2, 130) = 3.01$, $p < .05$, $\eta^2_p = .044$). In the orthogonal planned comparisons, as expected, for all three measures, no difference emerged between the unspecified and the coherent conditions (H1a; understanding: $F(1, 65) = 2.93$, $p > .09$, Figure 1b; willingness to buy: $F(1,64) < 1$, Figure 1c; log reading time: $F(1,65) < 1$, Figure 1d), whereas these two conditions (coherent and unspecified) outperformed the incoherent condition (H1b). They yielded better understanding ($F(1,65) = 9.59$, $p < .003$, $\eta^2_p = .129$), greater willingness to buy ($F(1,64) = 6.79$, $p < .011$, $\eta^2_p = .096$), and higher reading fluency ($F(1,65) = 4.96$, $p < .029$, $\eta^2_p = .071$) than the incoherent condition.

Mediation Analysis: Fit with previous knowledge mediates the effect of direction of influence on sense of understanding, causal-claim acceptance, and reading fluency (H3)

In the one way ANOVA, the effect of the direction of influence on fit to previous knowledge was significant ($F(2,128) = 8.26$, $p < .001$, $\eta^2_p = .114$). When, as expected, there was no difference between the unspecified and the coherent conditions ($F(1,64) = 1.04$, $p > .312$), while these two conditions yielded higher ratings than the incoherent condition ($F(1,64) = 14.01$, $p < .001$, $\eta^2_p = .180$).

Because, as predicted, no difference emerged between the coherent and unspecified conditions and both were better than the incoherent condition (higher understanding and willingness to buy and shorter reading time), for the mediation analysis, we compared the incoherent condition to the coherent and unspecified condition as a group.

To examine the mediating role of fit with previous knowledge, we used the PROCESS macro based on Model 4, proposed by Hayes (2013) (1,000 bootstrap samples).We performed the process analysis separately for each outcome variable. Specifically, we regressed coherence (unspecified + coherent vs. incoherent) as the independent variable, and fit with previous knowledge as the mediators on sense of understanding (first analysis), willingness to buy

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(second analysis), and reading fluency (third analysis). In line with H3, we found that fit with previous knowledge mediated the effect of coherence on sense of understanding (β= .51, *SE* = .15, CI 95%: .25 to .80), willingness to buy (β= .46, *SE* = .14, CI 95%: .20 to .76), and reading fluency (β= .60, *SE* = .17, CI 95%: .28 to .96).

d) Discussion

In study 1, we demonstrate that text coherence achieved by directional verbs has positive effects on text understanding, causal-claim acceptance (willingness to buy), and reading fluency for short causal chains. Importantly, results clarify the way previous knowledge is expressed in the explanations. Specifically, we show directional verbs convey previous causal information when these verbs enable accommodation of the novel information to previous knowledge.

Study 2

In study 1, we demonstrated that participants are sensitive to the direction of influence for short chains. We designed study 2 to demonstrate the same holds for longer chains (H2 and H3).

e) Method

i. *Participants and design*

Seventy-four undergraduate students (males = 14.9%, M_{age} = 31.20; SD_{age}= 8.08) participated for credit in a web-based study using a within-subjects design. Participants read three different stories, one for each experimental condition (incoherent, unspecified, and coherent). The stories were assigned randomly to the conditions.

ii. *Procedure and materials*

We constructed three stories with three versions each: incoherent, unspecified, and coherent. The stories involved (1) a product that reduces join pains, (2) an ecological ball that cleans laundry without a detergent, and (3) a bandage that rapidly heals wounds (the basic story was taken from Fernbach et al., 2013).

In the story on the product that reduces joint pain, we told participants (verbs in italic are those used in the incoherent/unspecified/coherent conditions, respectively), "The Earth's gravity is responsible for a lot of joint pain that we feel. Hydro-Bean is a product that helps reduce arthritis pain because it *strengthens/ interferes with/weakens* the negative effects of gravity. How does it work? This kind of bath is located within a container which is sealed to light and sound. The user is lying on his back in the water at body temperature. Salt added to water *strengthens/interfere with/weakens* the effect of gravity as it *makes it difficult for/determines the ability of /helps* the user to float. This leads to muscle relaxation, which *decreases /affects the state of/ expands* the spaces between the joints, *making it difficult for the/ affecting the nature of the/ allowing the* blood flow to the affected areas".

In the ecological-ball story, we told participants (verbs in italic are those used in the incoherent/ unspecified/ coherent conditions, respectively), "The eco-wash ball contains ceramic pellets and natural minerals. In the washing process, when the ball is in contact with the water, the ceramic pellets discharge negative ions. The negative ions *join water molecules into bigger particles/ affect the size of water molecules/ dismantle water molecules to smaller particles*, which *disturbs/ affects/ facilitates* their ability to penetrate into the fabric fibers and to remove the dirt".

In the bandage story, we told participants (verbs in italic are those used in the incoherent/ unspecified/ coherent conditions, respectively), "Wounds usually develop bacteria that interfere in the healing process. Since the Bandageis padded with bubbles, they push away the pad from the wound and thus *prevent/affect the ability of the /allow* oxygen in the air to move and come into contact with bacteria that are in the wound. The contact of the bacteria with the oxygen *brings to life/affects the state of/ kills* bacteria as oxygen interferes with them etabolic processes."

iii. *Measures*

The measures were the same as in study 1 (adapted to the products; for personal sense of understanding and ability to explain, alpha Cronbach was= 0.83).In addition, we generated a score that measured the perceived efficacy of the product (the predicted covariation between the product usage and benefit attainment). Here we present the question for the bandage story. For the two other stories, see Appendix A2). We first told participants, "Suppose you are interested in examining the efficacy of the bandage in fast healing of wounds. An animal vet you know was willing to cooperate. Twenty dogs with a minor leg wound participated in the study; 10 were treated with a regular bandage and 10 with the new bandage. After three days (time considered short for wounds' healing), you checked if the wound healed." We then asked them two questions:

"Please evaluate, for how many of the 10 dogs treated with the new bandage the wound has cured after three days? (Specify a number between 0 and 10) ___."

Please evaluate, for how many of the 10 dogs treated with the regular bandage the wound has cured after three days? (Specify a number between 0 and 10) ___."

The measure of the expected efficacy of the product was the difference between the two numbers, and ranged between -10 (*the referent product is much less effective than the target product*) to 10 (*the target product is much more effective than the referent product*), where0 indicated no difference between the products in their expected efficacy. In fact, this measure is the normative measure of covariation between two

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dichotomous variables, known as ΔP (see, e.g., Cheng & Novick, 1992).

Causal-model theory (Pearl, 2000; Sloman, 2009; Spirtes, Glymour, & Scheines, 1993; Waldmann & Holyoak, 1992) asserts individuals hold causal models, when their structural features affect the expected covariation between the entities in the model. Consistent with this assertion and with empirical findings (see, e.g., Bes et al., 2012; Waldmann & Hagmayer, 2001; Perales, Catena, & Maldonado, 2004), we expected the perceived efficacy of the product (the expected covariation between the product usage and the benefit attainment) to be larger for the coherent condition (a chain model) than for unspecified and incoherent conditions (an apparent chain model).

f) Results

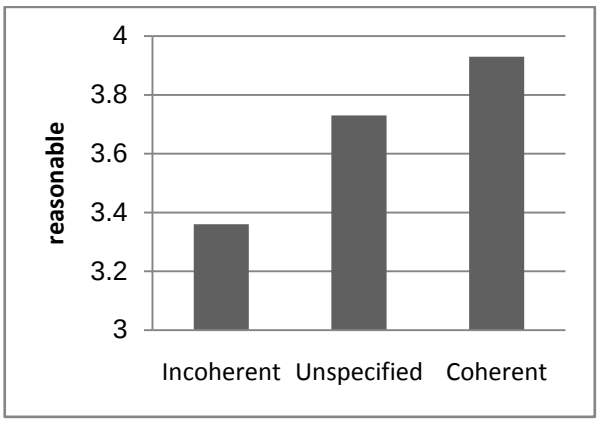
Table 2 and Figure 2 present the means and standard deviations of the three conditions of direction of influence (incoherent, unspecified, and coherent), for each of the measures: reasonability (manipulation check), understanding, willingness to buy, expected ΔP, and reading fluency (dependent variables) and fit with previous knowledge (the proposed mediator).

Table 2: Means (standard deviations) of the three experimental conditions (incoherent, unspecified, coherent) in reasonability (manipulation check), sense of understanding, willingness to buy, expected ΔP, reading fluency (dependent variables), and fit with previous knowledge (the proposed mediator)

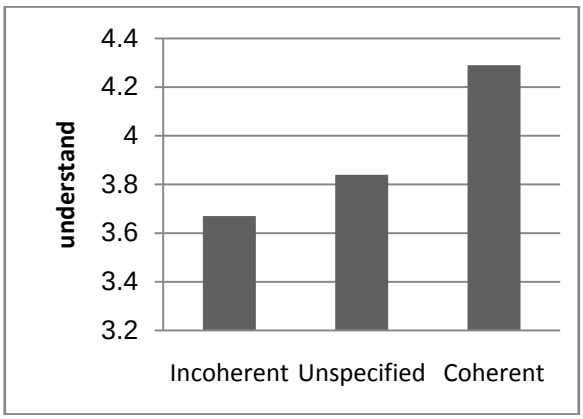
	Manipulation check	Dependent variables				Mediator
	Reason-ability	Under-standing	Willingness to buy	ΔP	Log reading time	Fit with previous knowledge
Incoherent	3.36 (1.42)	3.67(1.35)	3.22 (1.58)	-0.69 (4.24)	1.67 (0.24)	3.20 (1.49)
Unspecified	3.73 (1.36)	3.84 (1.22)	3.60 (1.50)	0.19 (3.82)	1.66 (0.23)	3.53 (1.33)
Coherent	3.93 (1.31)	4.29 (1.18)	3.91 (1.27)	1.35 (3.26)	1.62 (0.24)	3.85 (1.25)

Fig. 2. Study 2

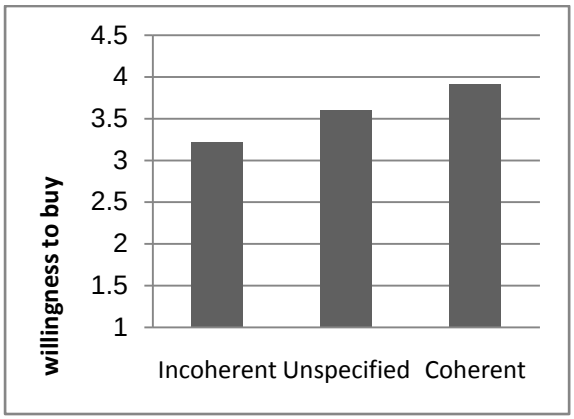
Ratings as a function of direction of influence (incoherent, unspecified, and coherent) in reasonability (2a), sense of understanding (2b), willingness to buy (2c), expected ΔP (2d), reading fluency (2e), and fit with previous knowledge (2f).



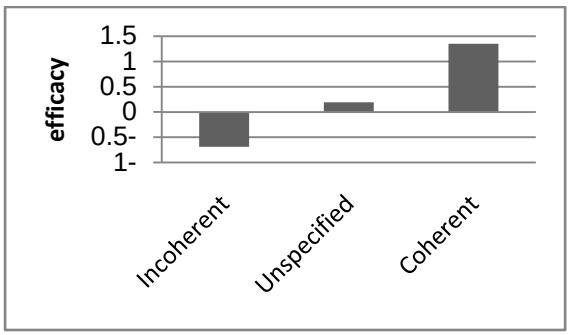
a. Explanation's Reasonability



b. Sense of Understanding



c. Willingness to Buy



d. Expected ΔP

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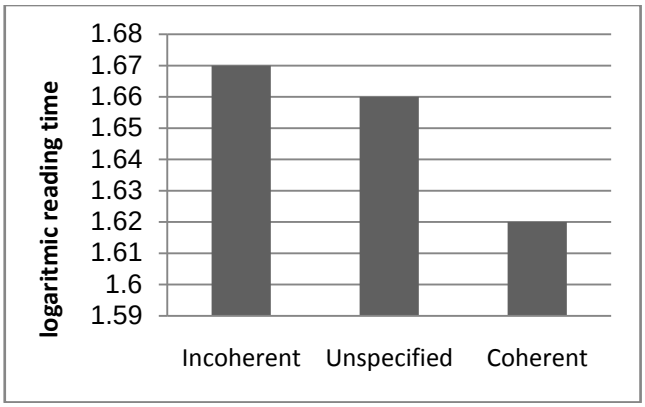
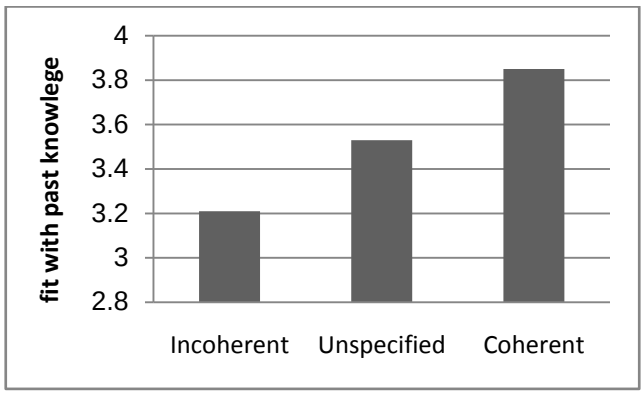


e. Reading Time



f. Explanation's fit with previous knowledge

g) Manipulation Check

The effect of direction of influence on reasonability ratings was significant (F (2, 146) = 4.10, p< .018, η^2_p = .053). As expected (see also Table 2 and Figure 2a), on average, reasonability ratings were similar for the incoherent and the unspecified conditions (F (1,73) = 3.19 ; p< .078), when reasonability of both was lower than for the coherent condition (F (1,73) = 5.08; p< .027; η^2_p = .065).

H2: Effects of text's coherence on understanding, causal-claim acceptance, and reading fluency

As predicted, the direction of influence had an effect on all measures (sense of understanding: F (2, 146) = 7.15, p< .001, η^2_p = .089; willingness to buy: F(2, 134) = 4.51, p< .017, η^2_p = .063; expected ΔP : F(2, 146) = 5.27, p< .006, η^2_p = .067; log reading time: F(2, 146) = 2.68, p< .07, η^2_p = .035). In the orthogonal planned comparisons, as predicted (H2a), no difference emerged between the unspecified and the incoherent conditions in all measures (see Table 2) (understanding : F (1, 73) < 1, Figure 2b; willingness to buy: F (1, 73) = 2.18, p< .145, Figure 2c; expected ΔP: F(1, 73) = 1.76, p< .189, Figure 2d; reading fluency: F (1,73) < 1, Figure 2e). Furthermore, in the orthogonal planned comparisons, as predicted (H2b), the coherent condition yielded better understanding [(F (1, 73) = 15.08, p< .001, η^2_p = .171], higher willingness to buy [F (1, 73) = 8.50, p< .005, η^2_p = .113], stronger expected ΔP [F (1, 73) = 9.57, p< .003, η^2_p = .116], and higher reading fluency (F (1, 73) = 4.73, p< .033, η^2_p = .061) than the incoherent and unspecified conditions.

Mediation Analysis: Fit to previous knowledge mediates the effect of direction of influence on sense of understanding, causal-claim acceptance, and reading fluency (H3)

In the one-way ANOVA, the effect of the direction of influence on fit to previous knowledge ratings was significant (F (2,146) = 5.79, p< .004, η^2_p = .073). In the planned comparisons, as expected, no difference emerged between the incoherent and unspecified conditions (Table 2 and figure 2f; F (1, 73) = 2.96, p< .090). Also, as expected, the coherent conditions yielded higher ratings for fit with previous knowledge than the unspecified and incoherent conditions (Table 2 and Figure 2f; F (1, 73) = 8.50, p< .005, η^2_p = .104). Because, as predicted, no differences emerged between the unspecified and the incoherent conditions in any of the measures, we tested H3 by comparing these two conditions to the coherent condition.

To examine the mediating role of fit with previous knowledge, we used the PROCESS macro based on Model 4, proposed by Hayes (2012) (1,000 bootstrap samples). We performed the process analysis separately for each outcome variable. Specifically, we regressed coherence (unspecified + incoherent vs. coherent) as the independent variable, and fit with previous knowledge as the mediators on sense of understanding (first analysis), willingness to buy (second analysis), expected ΔP (third analysis), and reading fluency (fourth analysis). In line with H3, we found that fit with previous knowledge mediate the effect of coherence on sense of understanding (β = .14, SE = .06, CI 95%: .03 to .26), willingness to buy (β = .93, SE = .88, CI 95%: .08 to 3.60), and expected ΔP (β = .31, SE = .13, CI 95%: .06 to .57). Yet, we found no indication for mediation for reading time (β = -.001, SE = .003, CI 95%: -.007 to .005).

h) Discussion

The results of study 2 converge with those of study 1, and demonstrate the positive effects of text coherence achieved by directional verbs (text understanding, causal-claim's acceptance, and reading fluency) holds also for long chains. Results show coherent explanations are better than incoherent explanations not only in short chains (study 1) but in long chains as well (study 2). Yet, the effects of the conditions in which the direction of influence is unspecified depend on the explanation's length. In short chains (only one mediator – study 1), for unspecified verbs, because people easily complete the direction spontaneously, they in fact "render" such explanations to be coherent. This makes unspecified explanations as

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incoherent explanations. The ability to spontaneously complete the direction of influence becomes almost impossible when more than one mediator variable is present, thus making unspecified verbs almost uninformative and thus incapable of conveying previous knowledge that could facilitate text comprehension. Hence, for long chains, texts in which the directional verbs are unspecified are as "bad" as texts in which the directional verbs are incoherent (incompatible with previous knowledge). Thus, including coherent directional verbs in explanations that contain more than one mediator is essential to achieve the positive effects mentioned. Importantly, as explained before, to make the explanation incomprehensible, all the verbs do not need to be unspecified or incoherent; that some of them are is enough (as was the case in study 2).

Study 3

In study 1, we demonstrated that participants are sensitive to the direction of influence for short chains. In study 2, we demonstrate the same pattern holds for longer chains. Yet, participants might have reported a higher understanding when the text included a coherent direction of influence, simply because they experienced fluent reading and not because they really understood. Rawson and Dunlosky (2002) demonstrated that processing that feels easy leads people to assume their mastery is high, but if processing feels difficult, they assume their mastery is low. However, processing fluency does not affect participants' objective comprehension. The aim of study 3 was to examine this possibility. The causal explanation we used was on a white-colored Cling wrap that keeps food fresh for longer (taken from Fernbach et al., 2013). We expected the participants' actual comprehension to be higher in the coherent condition than in the unspecified condition.

i) Method

i. *Participants and Design*

Forty-six undergraduate students (males = 19.6%, M_{age} = 31.35; SD_{age}= 10.18) participated for credit in a web-based study. They were randomly assigned to either the coherent or incoherent condition.

ii. *Procedure and Materials*

We exposed participants to one of two versions—coherent or incoherent—of an explanation of a new product: a white-colored Cling wrap that keeps food fresh for longer. We told participants (verbs in italic are those used in the coherent/ incoherent conditions, respectively), "Foods that are exposed to light waves *absorb their energy/are affected by their energy.* This energy *breaks the bonds holding /affects the bonds between* amino acids, *there by distorting/ determining* its texture and its freshness. The white color wrap *prevents /interferes in* this process, since white atoms tend to *oscillate/react* when hit by light waves. This *oscillating pushes away/reaction* of the white atoms *influences* the light waves, preventing them from spoiling food."

iii. *Measures*

We used the same measures as in study 2 (adapted to the stories). In addition, we asked participants to explain how the white color of the wrap keeps food fresh for longer. Participants were told, "Now, we'd like to probe your knowledge about the white cling wrap. Please describe all the details you know about how the white color of the cling wrap keeps food fresh for longer".

To measure the perceived efficacy of the product, participants were told, "Suppose you are interested in examining the white-color cling wrap in keeping food freshness for longer. To do this, you took 40 sandwiches, and then wrapped 20 with the white cling wrap and 20 with a regular wrap. After three days, the freshness of the sandwiches was checked.

"Please evaluate how many of the 20 sandwiches wrapped with the white cling stayed fresh after three days (specify a number between 0 and 20). ___

Please evaluate how many of the 20sandwiches wrapped with the regular wrap stayed fresh after three days (specify a number between 0 and 20). ___ "

j) Results

Sense of understanding, willingness to buy, expected ΔP, and reading fluency

As expected (H2b), the direction of influence affected and in the predicted direction all the measures (sense of understanding: F (1, 44) = 6.79, p< .012, η^2_p = .134, $M_{unspecified}$= 3.93, SD = 1.66 vs. M coherent = 5.04, SD = 1.21); willingness to buy: F(1, 42) = 2.95, p< .093, η^2_p = .063, $M_{unspecified}$= 3.68, SD = 1.24 vs. M coherent = 4.25, SD = 1.00; expected ΔP: F(1, 42) = 4.83, p< .033, η^2_p = .099, $M_{unspecified}$= 13.64, SD = 17.40 vs. M coherent = 25.42, SD = 18.82).

i. *Reading Time*

As expected, in the unspecified condition, reading time was longer than in the coherent condition ($M_{unspecified}$= 57.37, SD = 30.06 vs. M coherent = 51.82, SD = 31.76). Yet, the difference between the two conditions was not significant (F< 1).

ii. *Actual Understanding*

Two raters independently judged the quality of the explanations on a 5-point scale (0=*did not explain at all*, 4=*a full explanation*). The inter-raters' reliability was 0.80, and the actual understanding measure was based on the mean of their ratings. As expected, in the coherent condition, participants' explanations indicated they actually understood better than in the unspecified condition ($M_{unspecified}$= 0.77, SD = 1.03 vs. M coherent = 1.44, SD = 1.07; F (1, 44) = 4.55, p <.039, η^2_p = .096). If you recall, no difference emerged between the coherent and unspecified conditions in reading time, yet

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the means indicated a longer reading time in the unspecified condition. Hence, to ascertain that reading fluencydid not lead to the participant's better actual understanding in the coherent condition, we performed an ANOVA and included reading time as a covariate. The results were even stronger (F (1,43) = 7.13, p < .011, η^2_p = .142), suggesting text coherence established by information on direction of influence contributes to actual text understanding.

k) Discussion

Results of study 3 converge with those of studies 1 and 2 to demonstrate text coherence established by directional verbs positively affects sense of understanding, causal-claim acceptance (willingness to buy and expected delta P), and reading fluency. Importantly, we refute the rival explanation that the direction of influence contributes only to sense of understanding and not to actual understanding. Specifically, although reading fluency for the coherent explanation was higher, it did not create a false sense of understanding, because participants in this condition actually understood the text better, as evidenced in their explanations. Thus, text coherence produced by directional verbs creates real understanding.

IX. General Discussion

The aim of the present study was to try to clarify the source of the prominent power that mechanistic explanations have in our cognition. We did so by focusing on the mechanistic explanation's structure, and demonstrate text coherence achieved by directional verbs has positive effects on a text's sense of and actual understanding, causal-claim acceptance, and reading fluency. Importantly, we show directional verbs convey previous causal information when these verbs enable accommodation of the novel information to previous knowledge.

Specifically, we demonstrate the positive effects of directional verbs, for short chains (study 1, one "mediator" variable and two directional verbs) and for long chains (study 2 and 3, several mediators and several directional verbs).

Moreover, in study 3, we also demonstrate directional verbs affect actual understanding and not just one's sense of understanding, as suggested by studies showing reading fluency enhances sense of but not actual comprehension (e.g., Rawson and Dunlosky, 2002). Specifically, although reading fluency for the coherent explanation was higher, it did not create a false sense of understanding, because participants in this condition actually understood the explanation better, as evidenced in their explanations.

Finally, process analysis indicates fit of the direction of influence (stated in the explanation) with previous knowledge mediates the positive effects of directional verbs.

a) The importance of directional verbs versus unspecified and the length of the explanation

Results show that coherent verbs are essential in establishing understanding, causal-claim acceptance, and reading fluency for any explanation that constitutes more than one mediator. Specifically, in such cases the unspecified condition is as "bad" as the incoherent condition. For short explanations (only one mediator variable), we demonstrate that because people tend to complete the direction spontaneously, unspecified verbs are as "good" as coherent verbs. Yet, we should notice that also for short explanations it is better to provide coherent verbs than unspecified verbs. This conclusion is based on the fact that in the unspecified condition about 25% did not assume any direction (14%) or an incoherent direction (11%). Moreover, although not significant, there was a consistent tendency in favor of the coherent as compared to the unspecified condition (reasonability: 3.95 vs. 3.86; understanding: 4.36 vs. 4.01; log reading time: 1.32 vs. 1.35; fit with previous knowledge: 4.06 vs. 3.83). This difference can have significant implications especially in marketing communications – a context characterized with high competition for the consumer's attention.

b) Theoretical Implications

Mechanistic explanations are explanations about the process by which an object (tangible or intangible) produces an effect (the benefit). Traditionally, the definition of a causal chain and its length focused on the number of variables or entities (Fernbach et al., 2013; Walsh & Sloman, 2011) and the number of links (number of variables+1) (Einhorn & Hogarth, 1985) the explanation comprises. Our study adds and focuses on two elements that are a vital part of the causal explanation's nature, by which previous causal knowledge is transferred, that are missing in the above definition. First, the links between any pair of adjacent variables in the chain are expressed by *verbs* that carry information on states, and actions that result in states changes. Second, these verbs can covey previous causal knowledge and thus can help in assimilating explanations, which happens only when the verbs specify directions that fit previous knowledge. Thus, proper directional verbs act as "glue" that integrates the information in the explanation to make the entire text understandable, persuasive, and easy to read. Failure to properly "glue" one or more of the preceding-state entities to the following-state entities in the chain characterizes poor explanations.

c) Policy Implications

Although the current study focused on explanations for products, our results can be applied to explanations in any area. Explanations are common and govern our ability to function and adjust. Identifying the structural elements through which previous knowledge is transferred provides a strong tool for practitioners in

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any area (e.g.,marketing, education, public policy, etc.), because it specifies the knowledge of how to build comprehensible, persuasive, and easy-to-read explanations.

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Appendix A1 (Study 1)

Spontaneous completion of the direction of influence for each story.

The plant story: "Above you were told that the plant has flower buds that disperse a substance that affects mosquitoes' alertness. What did you assume about the direction of influence? a. nothing; b. that they increase mosquitoes' alertness; c. that they decrease mosquitoes' alertness"

The sticker story: "Above you were told that a sticker helps one lose weight quickly because it contains an herbal extract that affects fat burning. What did you assume about the direction of influence? a. nothing; b. that it slows fat burning; c. that it accelerates fat burning"

The wet road story: "Above you were told that the product prevents slipping on wet roads, because it contains a substance that affects tire grip on the road. What did you assume about the direction of influence? a. nothing; b. that it reduces tire grip; c. that it increases tire grip"

The chewing gum story: "Above you were told that the chewing gum enhances concentration because it releases endogenous substances that affect one's level of concentration. What did you assume about the direction of influence? a. nothing; b. that it releases substances that decrease concentration; c. that it releases substances that increase concentration"

Appendix A2 (Study 2)

Measure of expected efficacy of the product

The hydro-bin story: "Suppose you are interested in examining the hydro-bin efficacy in reducing arthritis pain. To check it, you took 20 people who suffer from arthritis pain;10 were treated via the hydro bin for a month, and 10 were not treated by any means. After a month, you asked each whether he or she experienced a reduction in their joint pain.

Please evaluate how many of the 10 people treated with the hydro bin reported a reduction in joint pain after one month (specify a number between 0 and 10). ___

Please evaluate how many of the 10 people that were not treated reported a reduction in joint pain after one month? (Specify a number between 0 and 10). ___ "

The eco-ball story: "Suppose you are interested in examining the eco-ball efficacy. To check it, you took 20itemsand randomly assigned them such that 10 were washed with the eco ball and 10 with a regular washing powder. Then you checked whether the item was clean or not.

Please evaluate how many of the 10 items that were washed with the eco ball were clean (specify a number between 0 and 10). ___

Please evaluate how many of the 10 items that were washed with the eco ball were clean (specify a number between 0 and 10). ___ "

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