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On the prioritization of safety warnings in product manuals

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Abstract

Most warning research has focused on how to best present individual hazards on signs and labels. However, many products have multiple hazards and to date there has been very little research on how to effectively present multi-hazard warnings. The present paper studies the sequencing of safety warnings in product manuals using warning statements from manuals of three power tools, each having multiple hazards associated with their use, maintenance, and storage. This research also examines the relationship between statement orderings and several user-belief dimensions. One group of 25 participants ordered sets of warning statements based on how they believed the warnings should be listed in the manuals. Another group of 25 participants rated each warning statement on importance, injury severity, injury likelihood, and prior awareness. The results provide a quantitative summary of preferred statement order that could be useful in assembling warning lists in manuals. Three of the four belief dimensions had substantial negative correlations with mean rank; the fourth, prior awareness, showed a weaker relationship. Empirical assessment of warning statements might be useful in prioritizing multiple warnings in product manuals to better transmit product-related hazards to users.

Relevance to industry

The present study demonstrates a procedure that could be useful to product and equipment manufacturers on how to prioritize lengthy lists of warning hazards. Empirical determination of the sequencing of safety messages may increase the likelihood that important information will be read and decrease the likelihood of product liability suits that allege inadequate hazard warnings. © 1997 Elsevier Science B.V.

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1. Introduction

Manufacturers provide product (operator or owner) manuals as a means of enhancing utility and consumer satisfaction (Celuch et al., 1992). These manuals attempt to educate consumers on the safe assembly, use, and maintenance of their products, as well as informing the consumers of the hazards associated with their products' operation (Showers et al., 1992). In general, people want manuals when they have questions about the product (Wogalter and Baneth, 1994). However, product manuals are frequently difficult to read and understand. Additionally, important information is often not highlighted or salient and may therefore fail to capture the users' attention.

In the past decade there has been tremendous growth in research activity on hazard warnings. Most of the research has focused on how to best present information concerning individual hazards. However, consumer products and industrial equipment often have multiple hazards associated with them and, correspondingly, these products and equipment typically have numerous warnings listed in their manuals. Therefore there is a need to determine the procedures that produce product manual warnings that effectively communicate multiple hazards.

Only recently has research begun to investigate the factors that influence people's reading and understanding of warnings in product manuals. In one study, Young and Wogalter (1990) found that highlighting hazard warnings with conspicuous print and pictorials increased warning comprehension and memory. Wright et al. (1982) found that if a product is perceived as unfamiliar or complex to operate, people report being more likely to read the accompanying manual. Lust et al. (1992) identified several variables that predict product manual readership. They found that people were less likely to read a manual if they believed they already knew how to use the product, if they felt pressured for time, or if they were better educated, whereas people were most likely to read the manual if they believed the manuals to be useful and helpful.

Research has also examined how the placement of warnings in product manuals can either deter or facilitate reading. Frantz (1994) found that incorporating warnings within the general instructions of a

manual increased the likelihood of reading. Wogalter et al. (1986) found that placing safety warnings before a set of task instructions produced greater compliance than warnings placed after the instructions. Showers et al. (1993) used eight focus groups to explore consumer behavior and perceptions of product manuals. In particular they examined whether obvious warnings that described already well known hazards in product manuals influenced people's willingness to read them. The focus groups reported that placing obvious warnings first in a list had the potential of offending consumers' intelligence, and may possibly deter them from reading important information located further down the list. A follow up experiment conducted by Lust et al. (1995) sought to confirm these focus group results. The authors compared the presentation of obvious warnings ordered first in a list to distributing the obvious warnings throughout the list. However, the study failed to show a difference between conditions. These results suggest that the factors that produce the best method of sequencing hazard warnings in product manuals have yet to be determined.

Recent research with over-the-counter pharmaceuticals has provided a potential method that might be useful in deriving a preferred ordering of warnings in product manuals. Vigilante and Wogalter (1996a) had participants rank order drug label components on how they would like to see the information presented on package containers. The authors sampled three different population groups and used four different over-the-counter pharmaceuticals. The study was able to determine a consistent ordering of drug label components across the different drugs and population groups. The present study uses a similar method to determine a preferred ordering of the multiple hazard warnings in product manuals.

A group in the U.S. that approves electrical products based on industry standards is Underwriters Laboratories (UL). As part of the approval process, UL requires that electrical power-tool manuals include certain specific safety instructions (UL/ANSI, 1991). For example, UL requires the following:

“The phrases ‘Read all Instructions’ and ‘SAVE THESE INSTRUCTIONS’ shall appear and shall be the first and last items, respectively. The phrase ‘Read all Instructions’ shall be preceded by the

statement ‘Warning: When using electrical tools, basic safety precautions should always be followed to reduce the risk of fire, electric shock, and personal injury, including the following: [In the product manuals, this phrase is followed by a list of safety instructions and warnings].’ Equivalent wording may be used, except the signal word which is to remain ‘Warning.’”

In addition to the above, UL/ANSI (1991) requires a set of warnings that must appear in *all* electrical tool product manuals. The headings for these warnings are shown in Table 1. UL’s guidelines also include additional information to follow each heading not given in the table. UL/ANSI (1991) also requires that certain warnings be included for all grounded tools (e.g., grounding instructions and extension cords) and for all double insulated tools (e.g., replacement parts and polarized plugs). Additionally, a supplemental set of warnings are required for certain tools (e.g., circular saws and pneumatic hammers). The headings for the additional set of required warnings for a circular saw are shown in Table 2.

Although UL requires these safety warnings to be included in product manuals, they do not require the

Table 1
Headings for Underwriters Laboratories mandated safety warnings for all power tools

1.	Keep work area clean
2.	Consider work environment
3.	Guard against electrical shock
4.	Keep children away
5.	Store idle tools
6.	Don’t force tool
7.	Use right tool
8.	Dress properly
9.	Use safety glasses
10.	Don’t abuse cord
11.	Secure work
12.	Don’t overreach
13.	Maintain tools with care
14.	Disconnect tools
15.	Remove adjusting keys and wrenches
16.	Avoid unintentional starting
16A.	Extension cords
17.	Outdoor use extension cords
18.	Stay alert
19.	Check damage parts

Table 2
Headings for Underwriters Laboratories mandated warnings for circular saws

1.	Keep guards in place and in working order
2.	Keep blades clean and sharp
3.	Danger: Keep hands away from cutting area
4.	Support large panels
5.	Use rip fence
6.	Guard against kickback
7.	Lower guard
8.	Adjustments
9.	Use only correct blades in mounting
10.	Avoid cutting nails

warnings to be in any specific order (except for the first two statements mentioned previously). Currently, many manufacturers not only put these warnings first in their product manuals but present them in the order shown in Tables 1 and 2. However, the warnings that are listed first may be the most obvious or familiar to the consumer/user, and may not be the warnings that provide the most important hazard information. Specifically, for the circular saw, many manufacturers list the circular saw’s specific warnings after the general warnings.

The present study attempts to identify the kinds of warnings that people prefer to encounter first in product manuals. In addition, the warning statements themselves were examined with respect to four dimensions: the warning’s importance, the severity of injury that might occur if the warning is not obeyed, the likelihood of injury that might occur if the warning is not obeyed, and prior awareness of the warning. Three of these dimensions are factors that have been investigated in previous warnings research for various products. Wogalter et al. (1991) showed that while perceived injury severity and likelihood were both positively correlated with willingness to read warnings, injury severity had a much stronger relationship. Additionally product familiarity is strongly related to willingness to read warnings (e.g., Godfrey and Laughery, 1984; Wogalter et al., 1986), although the relationship is not as strong as with injury severity (Wogalter et al., 1991). Prior awareness of hazards is also related to product familiarity because people are generally aware of the hazards of familiar products. However, there are circumstances when people may be very familiar with a product

and may not be aware of all of its potential hazards (Godfrey and Laughery, 1984). In addition, prior awareness of hazards is connotatively related to, but not the same as, the concept of obviousness. As described earlier, warning obviousness was studied by Lust et al. (1995) and Showers et al. (1993) but the research showed equivocal results with respect to the reading of warnings. A fourth dimension investigated in this study, perceived importance of warning statements, has not been investigated in previous research. This variable was included because it was believed that people's impression of a warning's importance might be a critical factor in predicting the preferred statement order.

2. Method

2.1. Participants

Fifty students from North Carolina State University (NCSU) participated for credit in their introductory psychology course. One group of 25 participants (32% females) performed a rank-order task on the warnings from three power tools. Another group of 25 participants (28% females) rated the warnings on four dimensions.

2.2. Materials

The warnings were taken from the product manuals of three power tools: a gas powered chain saw, a circular saw, and a dry wall screw drill. These products were chosen because they have several potential hazards associated with their use, maintenance, and storage. Complete lists of warnings were derived for each power tool by combining the warnings contained in manuals from different manufacturers of the same power tool. For example, the list of warnings for the dry wall screw drill were taken from the product manuals developed by the Craftsman, Makita, and Milwaukee manufacturers. The lists of warnings were then given to five NCSU students, who were asked to assemble the warnings they believed should be combined into a single warning or eliminated because it was redundant with another warning. For example, the warnings "Do not wear loose jewelry while operating tool" and

"Do not wear loose clothing while operating tool" were combined into "Do not wear loose clothing or jewelry while operating this tool." Agreement by three people was used to determine which warnings should be combined or eliminated. This procedure ensured that the warnings comprised a complete set of potential hazards. The process produced 43 warnings for the chain saw, 44 for the circular saw, and 34 for the dry wall screw drill. Each warning was printed on individual strips of paper in 12-point Times font with a letter/number designation in the lower right corner. The letter indicated which tool set the warning was from and the numbers were randomly assigned to each warning to track the statements in the scoring and analysis procedures. The strips were then laminated with clear plastic for durability. The height of the warning strips varied depending on how much information was contained in the particular statement. However, the width of the warnings remained constant at 17.5 cm (6.88 in.).

2.3. Procedure

Initially a demographics questionnaire (asking gender, age, educational level, and ethnicity/race) was completed by all participants.

2.3.1. Ordering

The rank-order participants were told that they would be ordering warnings from the product manuals of 'three useful yet potentially dangerous power tools.' For each tool, the participants were asked to order the warnings, by placing first, the warning statements they thought were the most critical followed by the warnings they believed were less critical. Critical information was defined for participants as information needed for the tool's safe operation.

Participants were given a set of warnings for one tool and asked to order them. After they finished ordering the warnings for one tool, the experimenter recorded the order and gave them another set of warnings and this procedure was repeated until all three sets of product warnings were sorted. Participants were allowed as much time as they needed. Order of the three sets as well as the order of statements within the sets was randomized for each participant. When the ordering task was completed, participants were debriefed and thanked for their time.

2.3.2. Ratings

The participants in the ratings group were told that they would be making judgments of warning statements from the product manuals of three power tools according to four questions. The dimensions addressed by these items were: the importance of the statement, the severity of an injury that might result if the information in the statement is not adhered to, the likelihood of an injury that might result if the information in the statement is not adhered to, and prior awareness of the information in the statement. The ratings were made on nine-point Likert-type scales ranging from 0 (*absence of quantity*) to 8 (*maximum quantity*):

1. How *important* is this warning for the safe operation of this tool (0 = not at all important, 2 = somewhat important, 4 = important, 6 = very important, 8 = extremely important)?
2. How *severely* do you believe the injury would be if the warning was not complied with (0 = not at

all severe, 2 = somewhat severe, 4 = severe, 6 = very severe, 8 = extremely severe)?

3. How *likely* do you believe the injury would be if the warning was not complied with (0 = not at all likely, 2 = somewhat likely, 4 = likely, 6 = very likely, 8 = extremely likely)?
4. To what extent were you already *aware* of the information contained in this warning (0 = not at all aware, 2 = somewhat aware, 4 = aware, 6 = very aware, 8 = completely aware)?

All four scales were printed on one sheet of paper and placed in front of the participants while they rated the warnings. The order in which the three tool sets were presented as well as the order of statements within the sets were randomized for each participant. Participants recorded their ratings in spaces on a response sheet associated with each tool. For each tool, the response sheet listed, in numerical order, each warning's number/letter designation in one column with a space for a response. When the rating

Table 3

The top five and bottom five rank-ordered warnings for the chain saw (out of 43 warnings)

	Mean rank
<i>Top ranked</i>	
WARNING! KICKBACK may occur when the nose or tip of the guide bar touches an object, or when the wood closes in and pinches the saw chain in the cut.	10.24
To reduce the risk of serious or fatal injury to the operator or bystanders, never use the saw with one hand. You cannot control reactive forces and you may lose control of the saw, which can result in the skating or bouncing of the bar and chain along the limb or log.	13.36
Keep a good firm grip on the saw with both hands, the right hand on the rear handle, and the left hand on the front handle, when the engine is running. Use a firm grip with thumbs and fingers encircling the chain saw handles. A firm grip will help reduce kickback and maintain control of the saw. Don't let go.	14.76
Keep all parts of your body away from the saw chain when the engine is running.	14.80
Tip contact in some cases may cause a lightning fast reverse reaction, kicking the guide bar up and back towards the operator. Pinching the saw chain along the top of the guide bar may push the guide bar rapidly back towards the operator. Either of these reactions may cause you to lose control of the saw which could result in serious personal injury.	15.04
<i>Bottom ranked</i>	
Keep the handles dry, clean, and free of oil or fuel mixture.	29.68
Follow manufacturer's sharpening and maintenance instructions for the chain saw.	32.12
When transporting your chain saw, use the appropriate guide bar scabbard.	32.32
Spark arrester mufflers approved to SAR Standard J335b are standard on all chain saws to reduce the possibility of forest fires.	34.24
All chain saw service, other than the items listed in the operator's manual maintenance instructions, should be performed by competent chain saw service personnel. Only use replacement bars and chains specified by the manufacturer or the equivalent.	34.80

tasks were completed, participants were debriefed and thanked for their participation.

3. Results

3.1. Mean rank order of statements

The rank orders for each warning statement were averaged across participants, with lower mean ranks indicating greater preference (preferred to be placed earlier in the list). The top five and bottom five rank-ordered warnings for the chain saw along with their mean ranks are given in Table 3. The warnings with the lowest mean ranks concern the prevention of saw kick back and the correct way of holding the chain saw. The warnings with the highest mean rank concern the transportation, maintenance, and servicing of the chain saw.

The top five and bottom five rank-ordered warnings for the circular saw and their corresponding mean ranks are presented in Table 4. The warnings with the lowest mean ranks concern the use of protective equipment, prevention of being cut by the saw blade, avoiding use in an intoxicated condition, and electrical shock prevention. The warnings with the highest mean ranks concern the storage, maintenance and servicing of the circular saw. Specifically, three of the last five warnings concerned the tool's electrical cords.

The top five and bottom five rank-ordered warnings for the dry wall screw drill and their corresponding mean ranks are presented in Table 5. The warnings with the lowest mean ranks concern the use of drugs, the prevention of limb contact with the drill bit, the use of protective equipment, and the prevention of electric shock and explosion. The warnings with the highest mean ranks concern the storage and maintenance/part replacement of the tool.

Table 4
The top five and bottom five rank-ordered warnings for the circular saw (out of 44 warnings)

	Mean rank
<i>Top ranked</i>	
ALWAYS WEAR SAFETY GLASSES. Everyday eyeglasses have only impact-resistant lenses; they are NOT safety glasses.	8.92
DO NOT OPERATE THIS TOOL WHILE UNDER THE INFLUENCE OF DRUGS, ALCOHOL, OR ANY MEDICATION.	10.48
KEEP HANDS AWAY FROM CUTTING AREA. Keep hands away from blades. Do not reach underneath work while blade is rotating. Do not attempt to remove cut material when blade is moving.	10.56
NEVER touch the blade or other moving parts during use.	12.16
WARNING: GUARD AGAINST ELECTRICAL SHOCK BY PREVENTING BODY CONTACT WITH GROUNDED SURFACES, for example pipes, radiators, ranges, refrigerator enclosures. Also when using electric tools, basic safety precautions should always be followed to reduce the risk of fire, electric shock, and personal injury.	13.12
<i>Bottom ranked</i>	
DON'T ABUSE CORD. Never carry tool by cord or yank it to disconnect from receptacle. Keep cord from heat, oil, and sharp edges.	31.36
OUTDOOR USE OF EXTENSION CORDS. When tool is used outdoors, use only extension cords intended for use outdoors and so marked.	31.64
INSPECT TOOL CORDS PERIODICALLY. If damaged have repaired by authorized service facility. Stay constantly aware of cord location and keep it well away from the rotating blade.	32.64
When servicing use only identical XXXXX replacement parts.	35.24
STORE AND MAINTAIN TOOLS WITH CARE. When not in use tools should be stored in a dry, high place out of reach of children. Keep tools sharp at all times, and clean for best and safest performance. Follow instructions for lubricating and changing accessories.	35.28

Table 5

The top five and bottom five rank-ordered warnings for the dry wall screw drill (out of 34 warnings)

	Mean rank
<i>Top ranked</i>	
DRUGS, ALCOHOL, MEDICATION, STAY ALERT. Do not operate tool while under the influence of drugs, alcohol, or any medication. Watch what you are doing and use common sense. Do not operate tool when tired, and do not rush.	7.72
KEEP HANDS AWAY FROM ALL CUTTING EDGES AND MOVING PARTS.	7.90
ALWAYS WEAR SAFETY GLASSES WITH SIDE SHIELDS. Everyday eyeglasses have only impact resistant lenses; they are NOT safety glasses.	8.92
NEVER USE IN AN EXPLOSIVE ATMOSPHERE. Normal sparking of the motor could ignite flammable liquids, gases, or fumes.	10.24
VOLTAGE WARNING: Before connecting the tool to a power source (receptacle, outlet, etc.) be sure the voltage supplied is the same as that specified on the nameplate of the tool. A power source with voltage greater than that specified for the tool can result in SERIOUS INJURY to the user – as well as damage to the tool. If in doubt, DO NOT PLUG IN THE TOOL. Using a power source with voltage less than the nameplate rating is harmful to motor.	10.40
<i>Bottom ranked</i>	
MAINTAIN TOOLS WITH CARE. Keep tools sharp at all times, and clean for best and safest performance. Follow instructions for lubricating and changing accessories.	24.32
OUTDOOR USE EXTENSION CORDS. When tool is used outdoors, use only extension cords intended for use outdoors and so marked.	24.80
MAINTAIN CORDS WITH CARE. Inspect tool cords periodically and if damaged, have repaired by authorized service facility. Never carry tool by cord or yank it to disconnect from receptacle. Keep cord from heat, oil and sharp edges.	26.80
REPLACEMENT PARTS. When servicing, use only identical replacement parts.	28.20
STORE IDLE TOOLS. When not in use tools should be stored in a dry, and high or locked up. Place out of the reach of children.	29.44

3.2. Relationship of order and ratings

The mean rank-order data were combined with mean ratings of the four dimensions to determine the relationship between the statement scores for each tool separately. The intercorrelations are shown in Table 6. Note that Spearman's Rho is used for all correlations involving the rank-order scores (with the four dimensions), whereas Pearson r is used for all inter-correlations among the four rating dimensions.

The correlations indicate substantial negative correlations of the mean rank orders for three of the four rated dimensions. For all tools, warnings with lower ranks (preferred to be placed earlier in the list) were rated as having the most important information and conveyed risks that would produce more likely and more severe injuries. Prior awareness of the warning is significantly negatively related to mean rank for only the chain and circular saws. For these

Table 6

Inter-correlations between the statement mean-rank and belief dimension ratings

	Rank order	Importance	Severity	Likelihood
<i>Chain saw</i>				
Importance	-0.65 ^b			
Severity	-0.77 ^b	0.76 ^b		
Likelihood	-0.77 ^b	0.71 ^b	0.63 ^b	
Awareness	-0.60 ^b	0.47 ^b	0.59 ^b	0.50 ^b
<i>Circular saw</i>				
Importance	-0.65 ^b			
Severity	-0.74 ^b	0.86 ^b		
Likelihood	-0.62 ^b	0.15	0.06	
Awareness	-0.30 ^a	0.32 ^a	0.37 ^a	0.08
<i>Dry wall screw drill</i>				
Importance	-0.48 ^b			
Severity	-0.66 ^b	0.70 ^b		
Likelihood	-0.67 ^b	0.67 ^b	0.86 ^b	
Awareness	-0.30	0.07	0.46 ^b	0.53 ^b

^a $p < 0.05$, ^b $p < 0.01$.

two products, the warnings with lower ranks contained less known information. However, for the dry wall screw drill, prior awareness did not significantly relate to the rank orders of the warning statements.

4. Discussion

This study identified a preferred ordering of product manual warnings for three power tools. For all of the tools, the warnings with the lowest mean ranks (preferred to be placed first) tended to concern specific actions to be taken or avoided to prevent serious injury to the operator, tool and/or others. Also, these warnings tended to contain information critical for the initial use of the product. The warnings with the highest mean ranks tended to contain information that was not as specific or critical for the operation of the tool. In general the warnings with the highest mean ranks tended to deal with storage, maintenance, part replacement, and cord maintenance. These warnings tended to contain information important for later use of the product.

UL provides a list of warnings in an order with general statements placed first. However, although UL lists the warnings in this way they do not stipulate any specific order that manufacturers need to list the warnings (except the first two statements: "Warning: When using electric tools ..." and "Read and Save All Directions"). UL only requires that the warnings be present in the manual. The present results indicate that a different ordering than those shown in the UL specifications is preferred.

The present study also examined the relationship of statement order to four dimensions. Ratings on these dimensions were taken from a group of participants independent of those who ordered the statements. For all three tools the importance, injury severity, and injury likelihood ratings were shown to be substantially (negatively) related to the statement mean rank orders. Warnings that conveyed the most important information and could result in the most likely and most severe injuries if not complied with were preferred to be placed towards the top of the list. These results indicate that ordering of the statements are predictable and consistent.

The fourth dimension, prior awareness of the information, was more inconsistent than the other

three dimensions in its relation to statement order. For the chain saw the relation was strong. For the circular saw it was weaker (although significant). For the dry wall screw drill the relation was of the same magnitude as the circular saw, but because the number of statements was lower, it was not significant. The interesting aspect is that the concept of awareness is connotatively similar, although not identical, to the concept of obviousness. Both concepts concern people's prior knowledge and this factor has yielded equivocal findings in earlier studies. As mentioned earlier, Showers et al. (1993) and Lust et al. (1995) found inconsistent results for obviousness in their product manual research. Moreover, another knowledge-related concept, familiarity, has also shown inconsistent results with respect to product warnings (Godfrey and Laughery, 1984; Wogalter et al., 1991). It appears then that there is a complex relationship between people's knowledge and how they deal with products and warnings. Whether there are relevant moderating or latent variables needs to be determined in subsequent research.

It should be noted that the warning orders found in the present research are not necessarily the best possible arrangement of statements. Nevertheless, they are probably better than the orders currently found in most power tool manuals. The best possible arrangement may depend on other factors beyond the simple preference determination used here. Factors such as specific product attributes and semantic organization of the material (e.g., mechanical injury vs. electric shock, or personal injury vs. product damage) as well as other factors might be important in producing an optimal warning presentation.

Additional research should be conducted using other warnings-related dimensions to determine if they relate to the statement orders. It may be useful to compare the ratings and rankings of the statements by product experts (who are more likely to have knowledge of the tool's proper operation and 'hidden' hazards) and lay persons to determine if and how they differ. Moreover, other products should be examined to verify the generalizability of the present results, and if there is consistency across products, then there is firmer ground on which to establish guidelines. Further research is also needed to determine whether empirically-determined ordering of statements do in fact facilitate reading and usability.

Testing with free recall and recognition measures (Lust et al., 1995) as well as reaction time and actual product-use tasks will aid in this determination.

Prioritization of important warnings may also help in the presentation of statements for other kinds of products that contain several warnings on labels directly attached to the product (e.g., container labels for hazardous chemicals). Prioritizing the warnings may ensure that at least the statements which contain the most important information have a better chance of being seen (Vigilante and Wogalter, 1996b). Also, prioritization could be used in cases where the size of a product's label is limited (e.g., over-the-counter medications). In such cases, extensive lists of warnings could diminish legibility due to the resulting small print necessary to list all relevant information in a small space. The present methodology could be used to determine the statements that should be included (i.e., the most important information) and which information can be excluded or be presented in a longer list available elsewhere.

Applications of prioritizing information should be useful to manufacturers as they develop manuals for the safety and welfare of product users. Also, well designed product manuals could reduce potential legal liability claims of not adequately informing consumers of hazards associated with their products (Showers et al., 1992). Ordering the warnings properly may be one of the ways to offer this protection.

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