

Providing explanations to visitors  
affects inquiry behavior:  
A study of the Downhill Race Exhibit

Joshua Gutwill

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## Goals

This study tests two independent variables at the Downhill Race exhibit: Label copy (three versions) and Disk type (two versions). The dependent variables include:

- Holding time
- Physical engagement
- Intellectual engagement
- Figuring out that distribution of mass is the most important factor in the speed of the disks.

## Exhibit background

At this exhibit, visitors race two disks by rolling them down parallel tracks. The main question is: Which kind of disks will roll fastest? There are several variables that could affect the speed of the disks: air resistance, overall weight (heavy or light), or distribution of the weight (in

towards the hub or out towards the rim). Visitors run multiple races to investigate these variables. It turns out that the distribution of the weight is the most important variable: disks with more weight concentrated in the center will roll faster than disks with more weight located out by the rim.

## Summary

- Visitors were observed at Downhill Race with various types of Disks and different Labels.
- The holding time with Metal Disks was longer than with Wood Disks.
- The holding time was the same regardless of Label. There were no interaction effects of Disk and Label on holding time.
- The depth of engagement was the same regardless of Disk, but seemed to be best for the Label which contained only a Try This section. The Try This & What's Going On label suffered the most when the Wood Disks were used instead of the Metal Disks.
- The articulation of a valid theory occurred more often with Wood Disks than with Metal Disks, and with the Try This & What's Going On label. However, the Try This Only label and the Four Theories label benefited most from Wood Disks over Metal Disks.

## Method

On two separate occasions, March 24 and April 20, 2002 (both weekend days), we videotaped visitors at the Downhill Race exhibit. A total of 143 visitor groups were observed, 66 on March 24 and 77 on April 20.

### Different Disks — metal and wood

On March 24, the exhibit contained 5 Metal Disks. The metal Disks were found by our project team to be difficult to understand; they did not make obvious the variables of mass and distribution of mass. Moreover, they confounded variables and inadvertently introduced the extraneous variable of air resistance. Worse, air resistance was confounded with mass distribution, and thus could not be tested and controlled for by the visitor.

On April 20, we replaced the Metal Disks with Wood Disks. The Wood Disks contained metal weights, located near the hub or rim. The thickness and solidity was the same for all four disks, thus eliminating the issue of air resistance. Our intention in creating the Wood Disks was to help the visitor notice the two variables of mass and distribution of mass without introducing other variables and without confounding any variables. Photos of the two types of Disks are shown below.

Metal Disks



Wood Disks



### Different Labels

On both occasions (March 24 and April 20), we employed three different labels at the exhibit throughout the videotaping, switching the labels every 20 minutes. The three labels were:

- **Try This & What's Going On (TT&WGO):** This was the original label containing instructions on what to do as well as an explanation of the idea that distribution of mass is the most important factor in the speed of the disks.
- **Try This Only (TT Only):** This label omitted the What's Going On section found in the TT&WGO label.
- **Four Theories (4 Theories):** This label instructed visitors to run races, and asked them to decide which of four different theories best explained the behavior of the disks. The theories were: (a) More mass makes a disk go faster, (b) Less mass makes a disk go faster, (c) Mass near the hub makes a disk go faster, (d) Mass near the rim makes a disk go faster.

Photos of the three Labels are shown below.

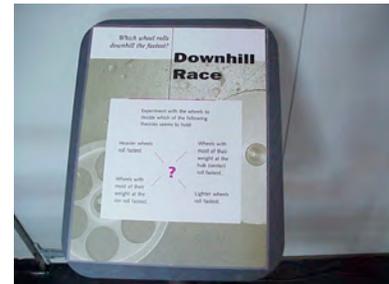
Try This &amp; What's Going On



Try This Only



Four Theories



In the analysis, we look at the different Disks and the different Labels.

## Results — Comparing Different Disks

### Holding time

The visitors spent slightly more time with the Metal Disks version of the exhibit than with the Wood Disks version.

The median holding times for visitors were:

Metal Disks = 2 minutes, 11 seconds

Wood Disks = 1 minute, 41 seconds

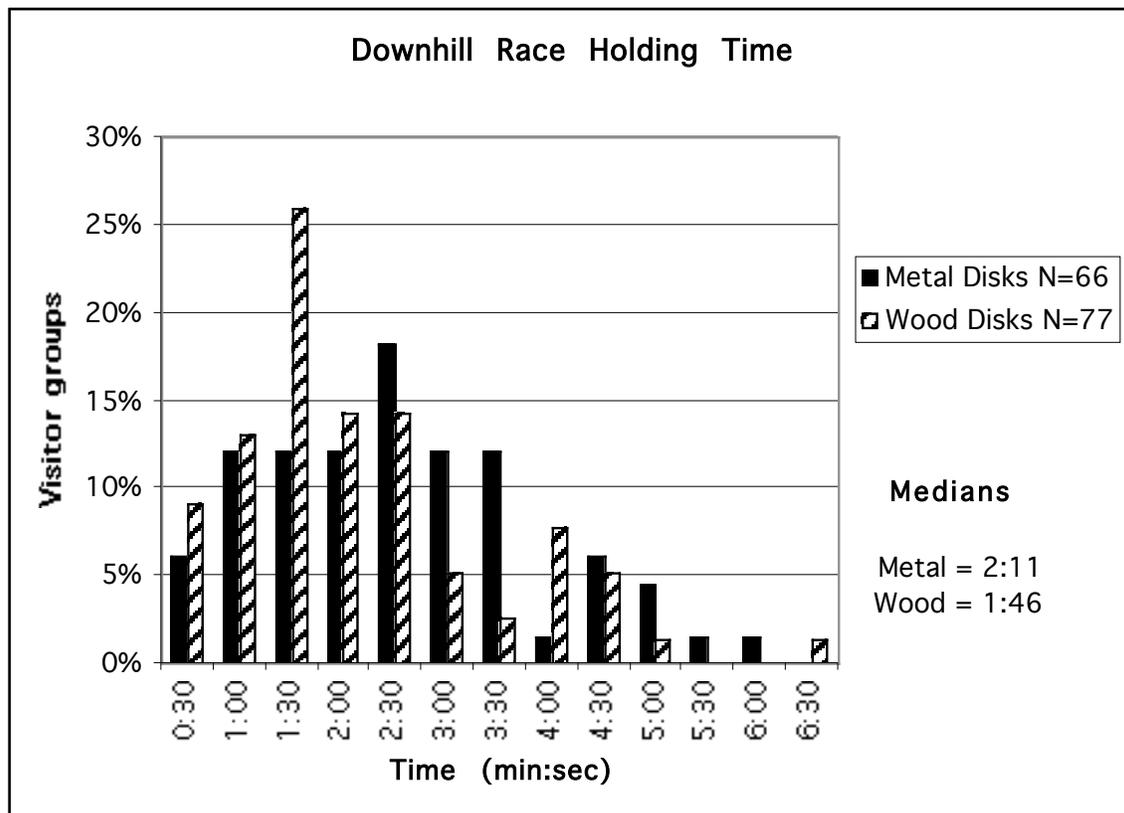
The mean holding times were:

Metal Disks = 2 minutes, 18 seconds

Wood Disks = 1 minute, 53 seconds

The difference in the means is marginally significant ( $F_{141} = 3.0$ ,  $p = .08$ ).

Figure 1 shows the distributions of holding time for the two Disk types.



**Figure 1.** Holding time for different types of Disks at exhibit.

(It is worth noting that the holding time distributions in both cases look fairly “normal,” rather than the more logarithmic or right-skewed distribution that is typical of science museum exhibits.)

### Depth of engagement

We rated visitors’ engagement on three axes: Quantity of Physical engagement, Quality of Physical engagement and Intellectual engagement. Quantity of Physical engagement was defined by the number of “fair” races a visitor group ran. Quality of Physical engagement measured the quality of the races – did visitors release both disks at the same time? Did they ever push or touch the rolling disks? Intellectual engagement was a measure of how often and with what quality visitors’ conversations reflected skills of investigation – predicting, hypothesizing, designing experiments, controlling variables, drawing conclusions, etc. All types of engagement were assessed by applying 2-point scales (High and Low) to each visitor group’s entire interaction with the exhibit. “High” means visitors demonstrated acceptable or exceptional engagement. “Low” means visitors showed unacceptable or no engagement.

There were no significant differences in visitors’ engagement levels between the Metal Disks and Wood Disks versions of the exhibit. Table 1 shows the number of visitor groups ranked “High” and “Low” in each engagement category for the two versions.

**Table 1.** Level of engagement of visitor groups

Engagement	Metal disks		Wood disks	
	High	Low	High	Low
Quantity Physical	54	12	55	22
Quality Physical	51	15	51	25
Intellectual	34	17	29	26

### Figuring out a valid theory

Visitors using the Wood Disks version of the exhibit articulated the correct theory (i.e., that disks with more mass at the center roll faster) significantly more often than visitors using the Metal Disks version of the exhibit ( $\chi^2 = 9.1$ ,  $p = .01$ ). Table 2 below shows the number of visitor groups in each version of the exhibit articulating correct or incorrect theories about what makes the disks roll faster.

**Table 2.** Visitor groups with correct theory for why disks roll faster

Visitors' theory	Metal disks	Wood disks
Correct theory	17	27
Incorrect theory	24	11
No theory articulated	22	30

**Correct theory:** Disks with mass at the center will roll fastest

**Incorrect theories:** Disks with more or less mass rolls fastest  
 Disks with mass at rim rolls fastest  
 Narrower disks roll fastest (less air resistance)  
 Combinations of above theories

**No theory articulated:** Visitors never articulate theory  
 Visitors speak foreign language  
 Visitors cannot decide among different ideas

## Results — Comparing Different Labels

### Holding time

There were no statistically significant differences in the amount of time visitors spent with the exhibit across the three different labels.

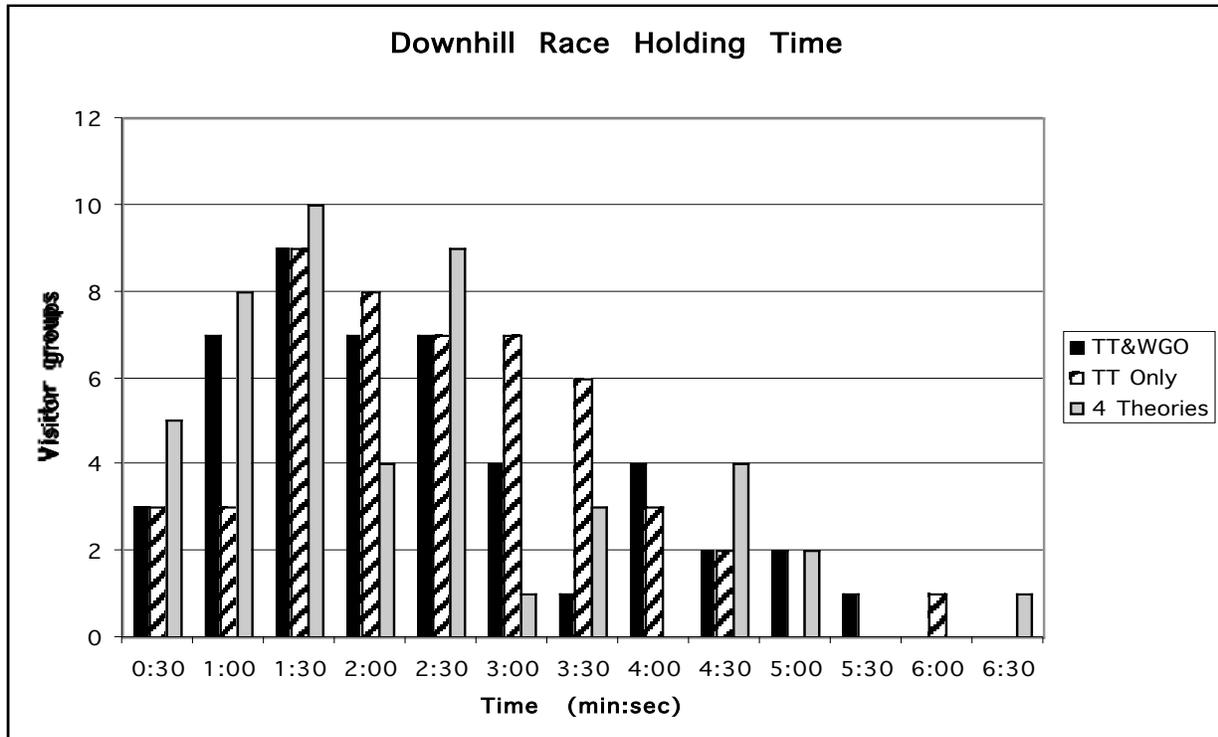
The median holding times for visitors were:

Try This & What's Going On (TT&WGO) = 2 minutes, 12 seconds  
 Try This Only (TT Only) = 1 minute, 50 seconds  
 Four Theories (4 Theories) = 1 minute, 32 seconds

The mean holding times were:

Try This & What's Going On (TT&WGO) = 2 minutes, 4 seconds  
 Try This Only (TT Only) = 2 minutes, 13 seconds  
 Four Theories (4 Theories) = 1 minute, 56 seconds

Figure 2 shows the distributions of holding time for the three Label types.



**Figure 2.** Holding time for each of the Label treatments.

### Depth of engagement

In contrast with the Disk comparison, there were statistically significant differences in visitors' engagement levels across Label treatments of the exhibit. The TT Only label seemed to fair the best, with a significantly larger fraction of groups scoring High in Intellectual engagement and a marginally larger fraction scoring High in Quality of Physical engagement. Table 3 shows the number of visitor groups ranked High and Low in each engagement category for the three Labels.

**Table 3.** Level of engagement of visitor groups

Engagement	TT&WGO		TT Only		4 Theories	
	High	Low	High	Low	High	Low
Quantity Physical	37	10	40	9	31	15
Quality Physical*	32	15	40	8	30	17
Intellectual**	19	16	29	8	15	19

\*Group difference significant at the .10 level ( $\chi^2 = 5.0$ ,  $p = .08$ ).

\*\*Group difference significant at the .01 level ( $\chi^2 = 9.2$ ,  $p = .01$ ).

### Figuring out a valid theory

Visitors seeing the TT&WGO Label articulated the correct theory (i.e., that disks with more mass at the center roll faster) significantly more often than visitors seeing the other two Labels ( $\chi^2 = 9.9$ ,  $p = .04$ ). This is not surprising, since simply reading the label's explanation aloud would be scored as articulating the correct theory. In fact, visitors in the TT Only label group, which did not provide an explanation in the label, most often articulated an incorrect theory. Table 4 below shows the number of visitor groups in each Label version of the exhibit articulating correct or incorrect theories about what makes the disks roll faster.

**Table 4.** Visitor groups with correct theory for why disks roll faster

Visitors' theory	TT&WGO Label	TT Only Label	4 Theories Label
Correct theory	20	12	12
Incorrect theory	8	18	9
No theory articulated	19	18	26

## Results — Interaction effects of Disk and Label

### Holding time

There were no interaction effects of holding time, meaning that all three Label groups decreased their holding time when the Metal Disks were replaced with Wood Disks ( $F_2 = 0.19$ ,  $p = .82$ ).

### Depth of engagement

The only interaction effect on engagement appears to be with the TT&WGO label group. That group had significantly more visitor groups in the “Low” category in all types of engagement when switching from Metal Disks to Wood Disks. In other words, only the TT&WGO group showed a marked change when using the Wood Disks, and that change was for the worse. The distributions of the other two Label groups did not essentially change across Disk types. This suggests that the Wood Disks make the variables so clear to visitors that when used in conjunction with the standard TT&WGO Label, visitors’ investigations decrease – they see the “correct” answer more easily so do not investigate as deeply. Table 5 shows the results.

**Table 5.** Interaction effects of Disk and Label on visitor engagement

Disk	Label	Quantity Physical			Quality Physical			Intellectual		
		High	Low	Fisher p value	High	Low	Fisher p value	High	Low	Fisher p value
Metal	TT&WGO	18	0	<b>.01</b>	16	2	<b>.02</b>	11	4	<b>.09</b>
Wood	TT&WGO	19	10		16	13		8	12	
Metal	TT Only	21	5	.99	21	5	.71	16	3	.45
Wood	TT Only	19	4		19	3		13	5	
Metal	4 Theories	15	7	.99	14	8	.99	7	10	.99
Wood	4 Theories	17	8		16	9		8	9	

### Figuring out a valid theory

Consistent with the depth of engagement results, the TT&WGO did not seem to be helped by switching from Metal Disks to Wood Disks. This is not too surprising, since the TT&WGO Label explains the phenomenon, so having Disks that clearly separate the variables may be less important. In fact, the Wood Disks did marginally help the TT Only and Four Theories label groups. Again, this supports our conclusion that the clarity of the Wood Disks is most helpful to visitors who are forced to figure out the correct theory themselves. Table 6 shows the breakdown of theories held by groups in each Disk and Label version.

**Table 6.** Interaction effects of Disk and Label on visitors' theories

Disk	Label	Correct theory	Incorrect theory	Fisher p value
Metal	TT&WGO	8	3	.99
Wood	TT&WGO	12	5	
Metal	TT Only	5	14	<b>.06</b>
Wood	TT Only	7	4	
Metal	4 Theories	4	7	<b>.08</b>
Wood	4 Theories	8	2	

## Conclusion

Changing the Disks clearly had an impact on how visitors used the Downhill Race exhibit. There seemed to be a trade-off in switching from Metal disks to Wood disks: On one hand, Wood disks decreased overall holding time, and discouraged the TT&WGO group from engaging as deeply with the exhibit. On the other hand, it helped more visitors, particularly in the TT Only and Four Theories groups, figure out the correct theory behind the disks' behavior.

Changing Labels also had an impact, and again there was a trade-off. Although the TT&WGO label helped most visitors get to the correct theory underlying the disks' behavior, the TT Only label seemed to help more visitors become more deeply engaged with the exhibit. The Four Theories label seemed to help visitors the least, because it encouraged neither the correct theory nor deeper engagement.

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