

Science Learning in Informal Environments

Jon D. Miller

**Professor and Director
Center for Biomedical Communication and the
International Center for the Advancement of Scientific Literacy
Feinberg Medical School
Northwestern University
Chicago, Illinois**

Over the last 50 years, research on the public understanding of and attitudes toward science has undergone a fundamental paradigm shift.

- n Most of the earlier empirical work was built on a warehouse model that assumed that individuals acquire pieces of science information from various sources and store this information in a mental warehouse. When new issues or problems arise, the individual turns to his or her shelf of knowledge and retrieves the needed information.**
- n Just as warehousing has changed into a just-in-time system in the distribution of materials, information seeking by adults has changed into a just-in-time system. The growth of the Internet has facilitated and accelerated this process, but the process was already underway BI.**

There is broad agreement that children and adults learn about science and technology from a variety of sources, but there is less agreement about how this learning process takes place. Building on continuing scholarship by psychologists and other learning theorists, I will:

- n describe a framework for understanding the processes through which children and adults learn about science, technology, and other complex subjects,**
- n use two examples of learning complex constructs to illustrate this process, and**
- n discuss the implications of this model for model for educational programming, science communications, and future research.**

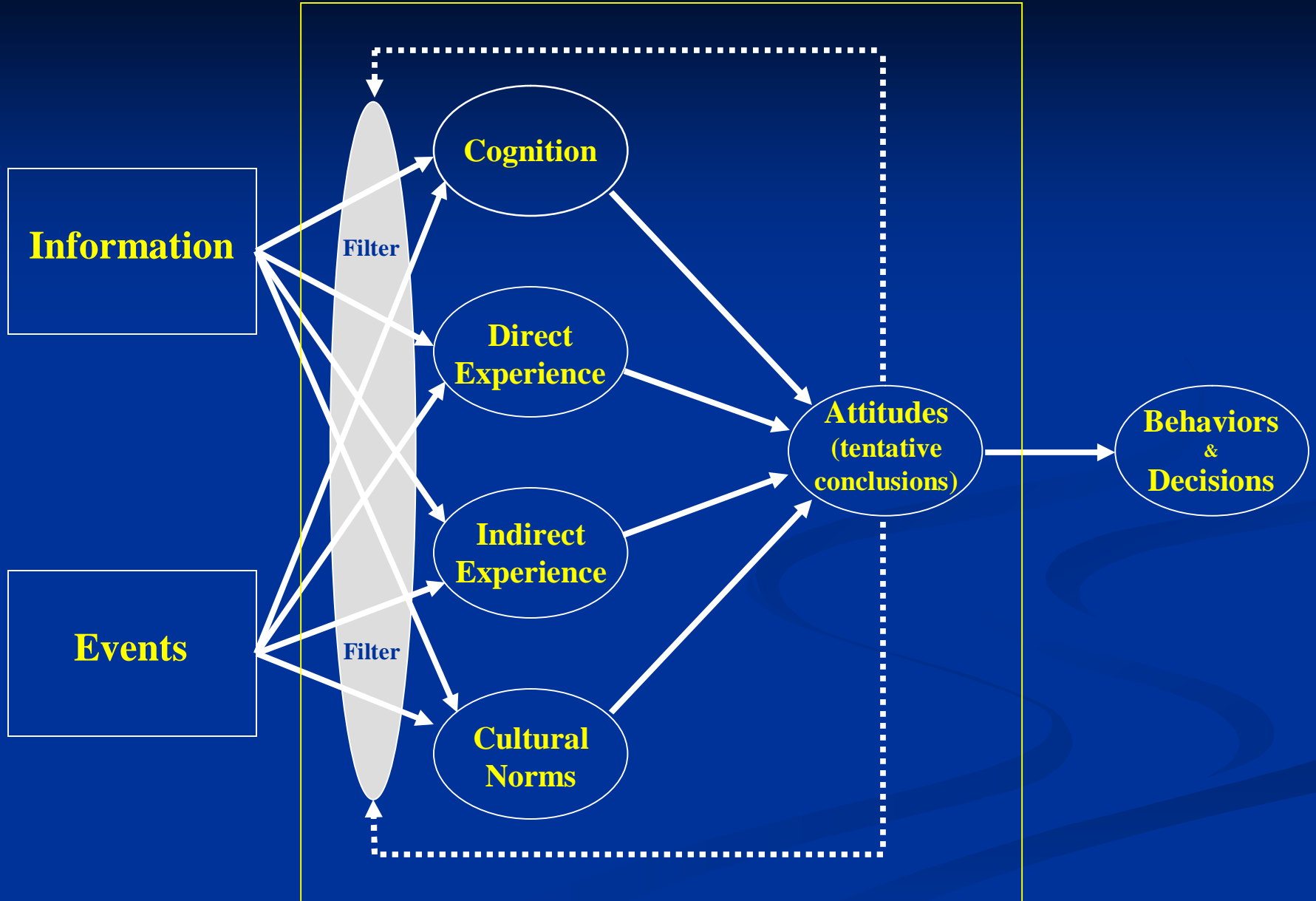
There is a growing level of acceptance of a set of learning models built on the last three decades of work by Robert Sternberg and his students and colleagues. His recent co-authored book *Complex Cognition* has been especially helpful in thinking about child and adult learning of complex scientific constructs (Sternberg and Ben-Zeev, 2001).

The core concept in this model is a schema.

A schema is:

- n A psychological construct. It pertains to the structure and organization of information and the use of this information in thinking and learning. It is an abstraction.**
- n It is not biological unit. You cannot see it with a microscope.**

Schema



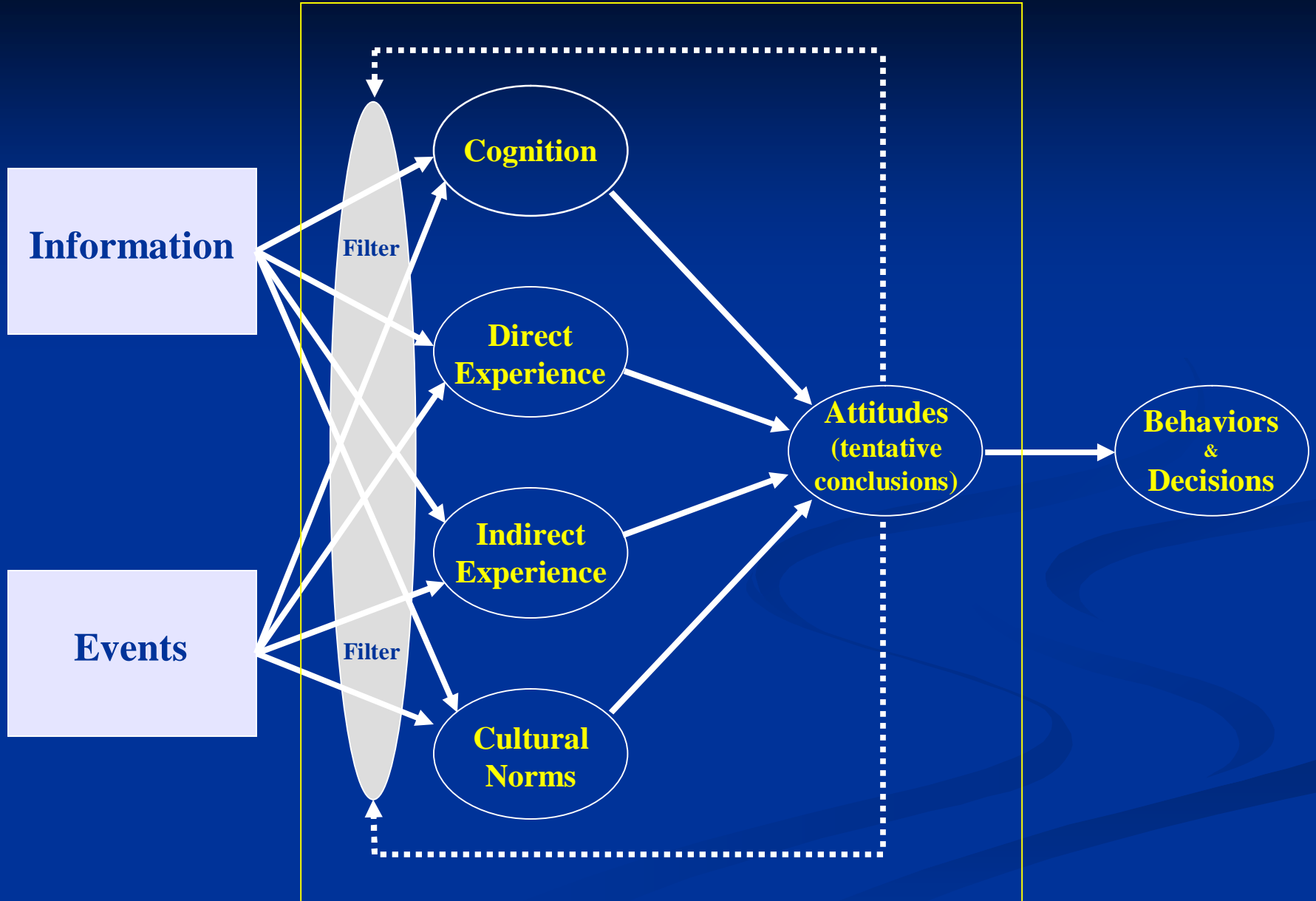
For students in formal programs, cognitive development has too often been cast in terms of the acquisition and retention of specific information.

- n The present emphasis on testing has been misinterpreted by many teachers, students, and parents as being designed to measure factual recall rather than deeper understanding.**
- n One of the advantages of looking at formal learning as a schema based process is that it focuses on the development of construct understanding – including attitudes – and places substantially less emphasis on fact or concept recall *per se*.**

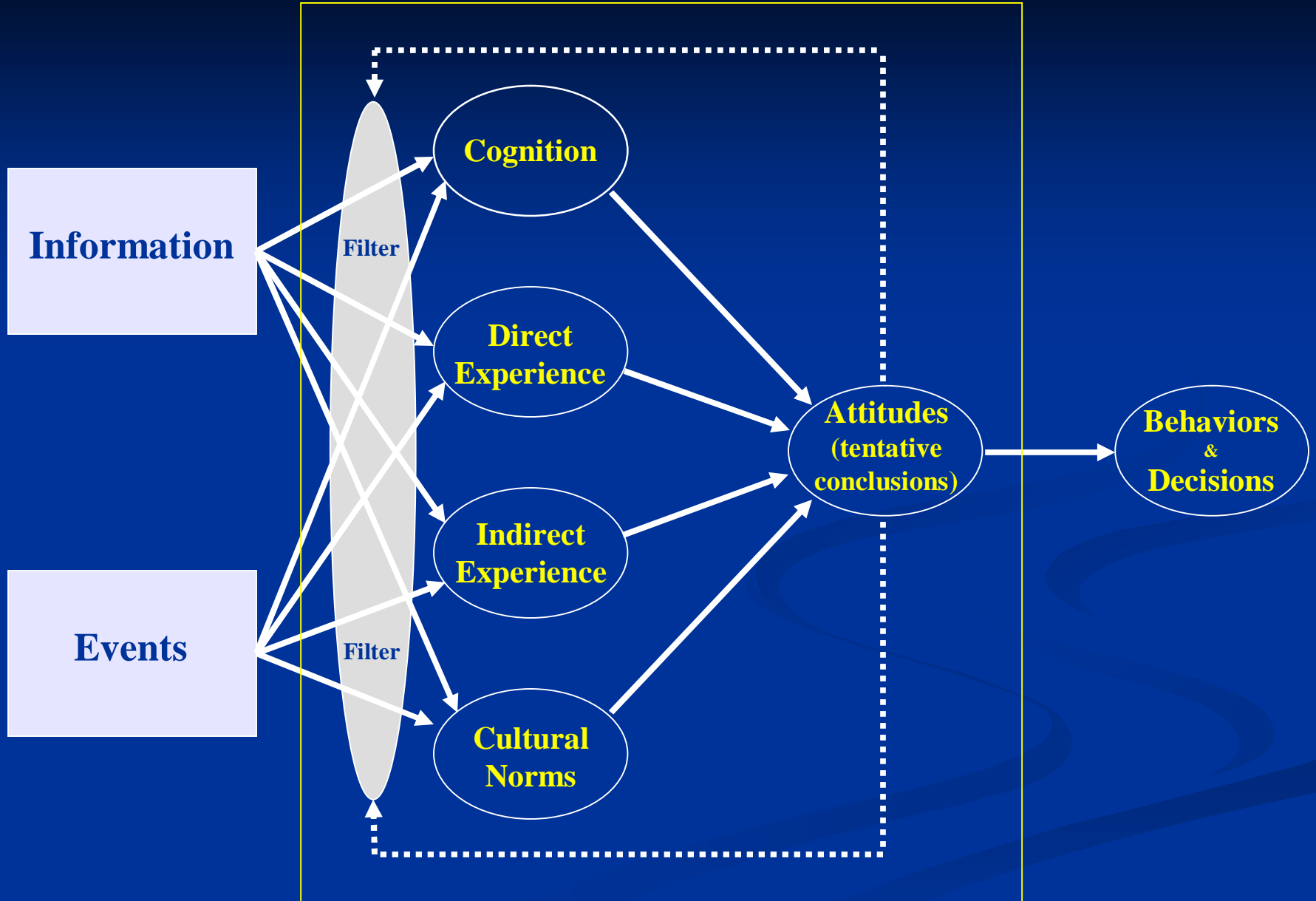
If we think about science learning in formal settings in schema-based terms, we should then see adult learning as the continued building of schemas and the use of existing schemas as heuristic tools to make sense of new and unfamiliar constructs or issues.

- n Adults are exposed to and receive information from a wide array of sources each day – print media, broadcast media, conversations with other persons, online, and from personal experiences. Some of this exposure is passive and some is purposive.**
- n Some information and experiences are produced by events – a tsunami, a hurricane, or the enactment of a law. Most individuals have little or no influence on the nature or timing of events.**

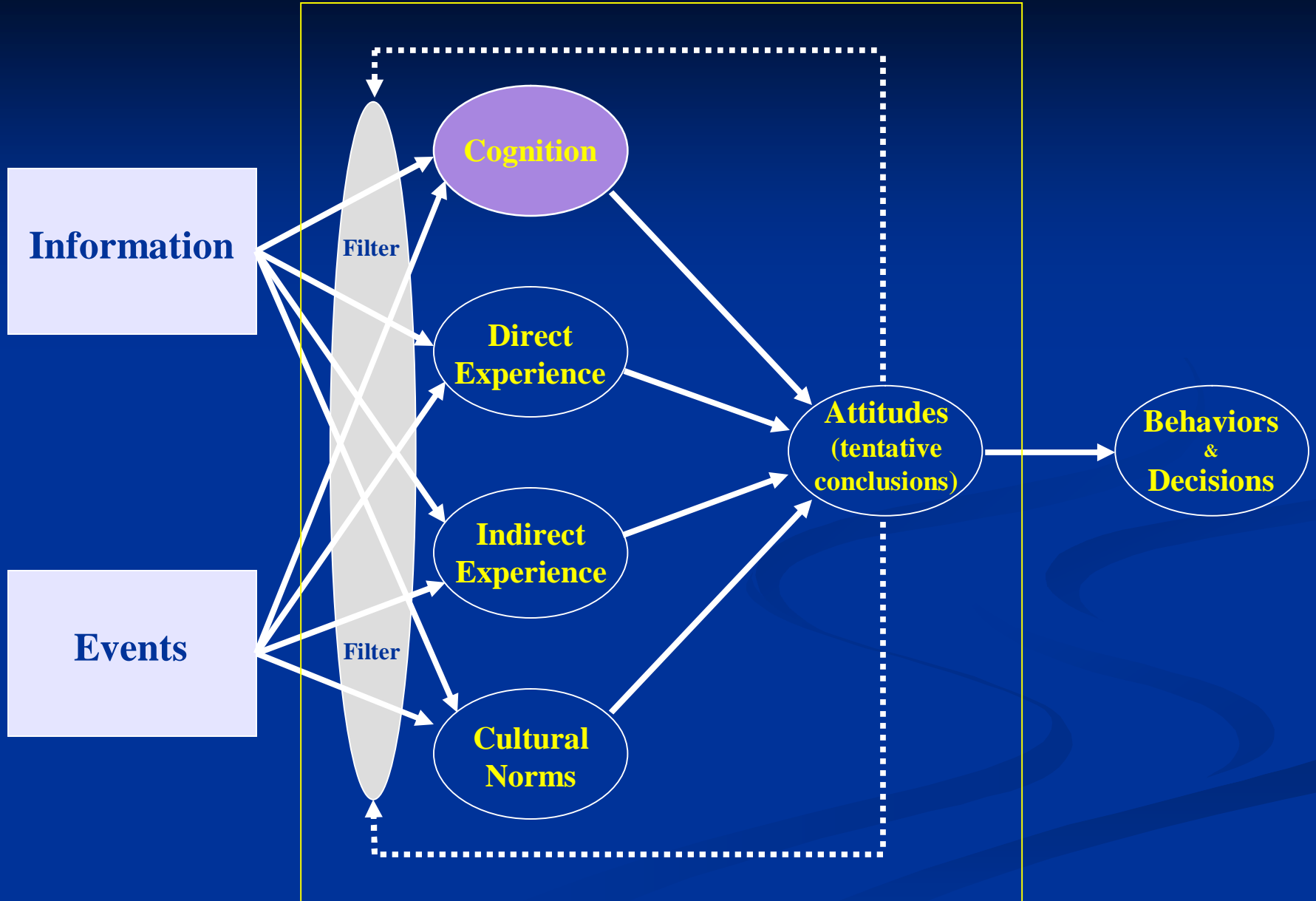
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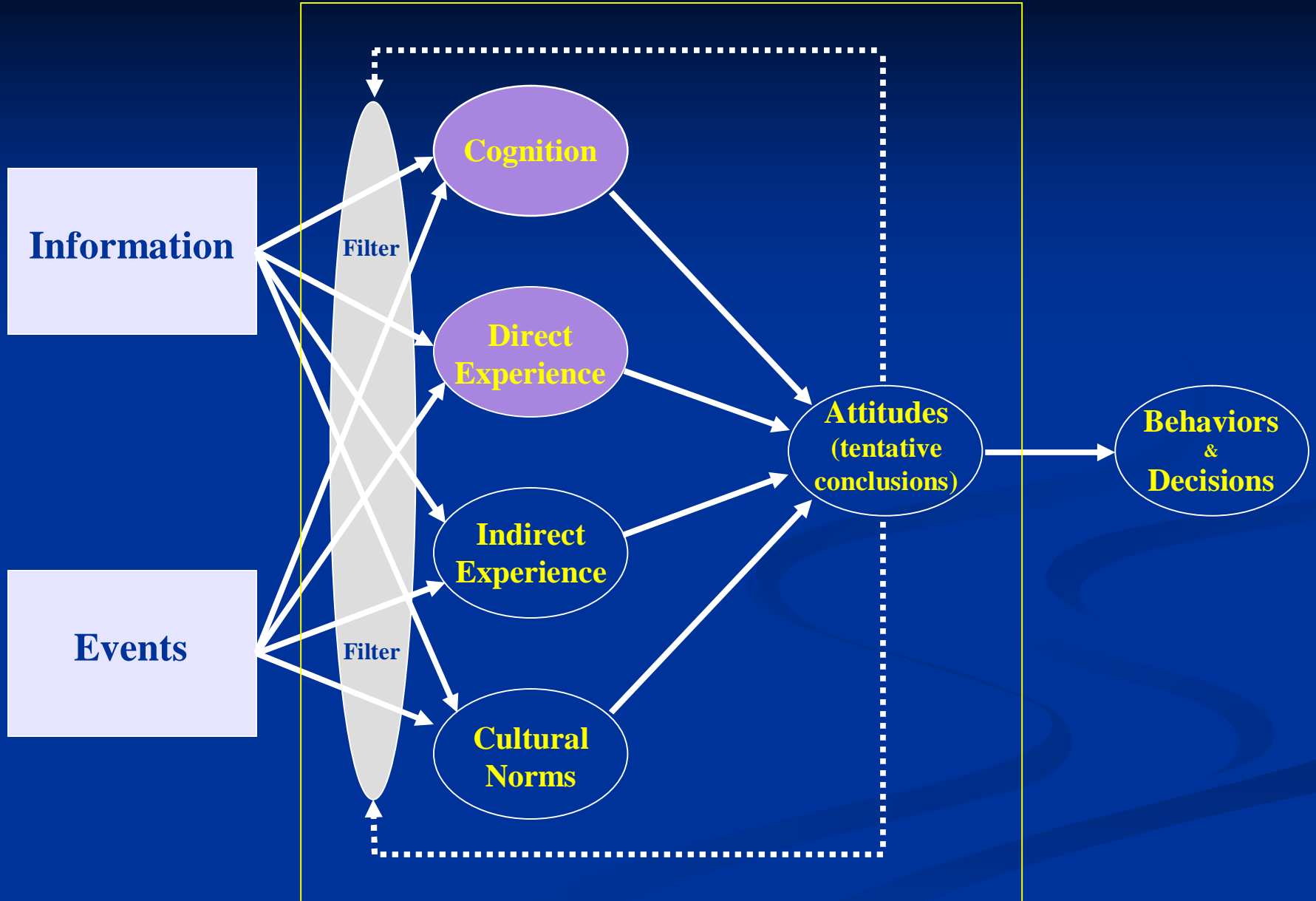
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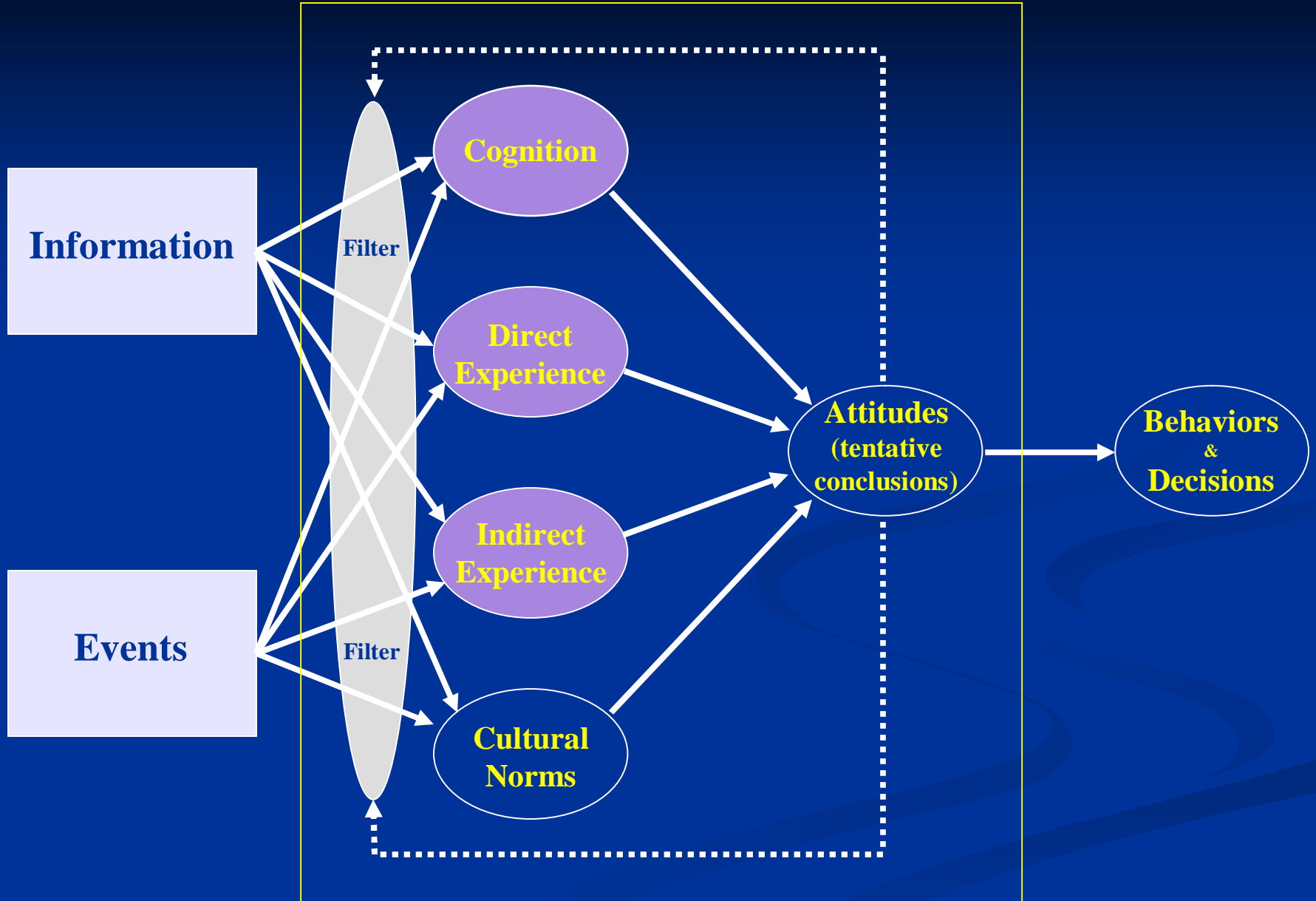
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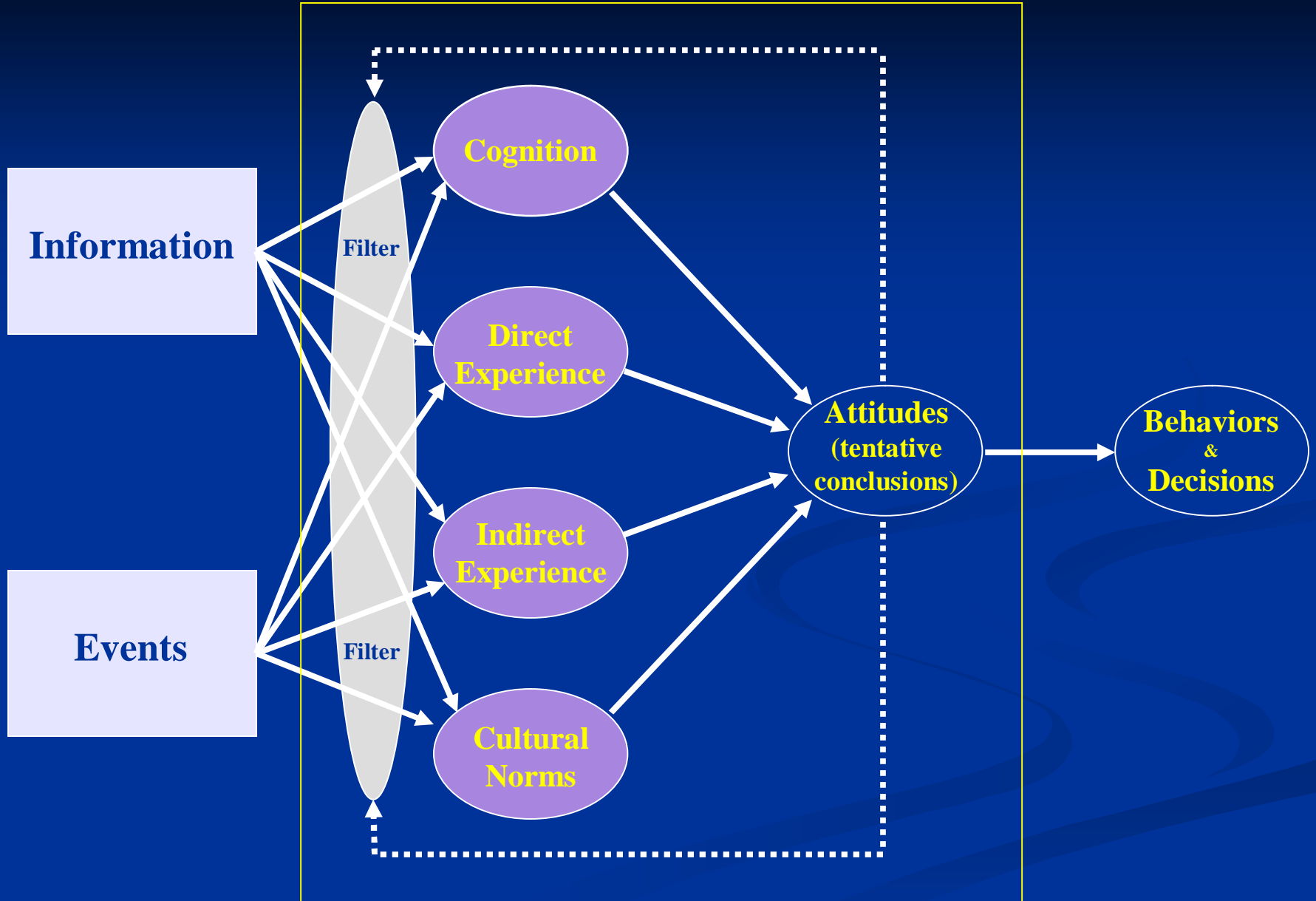
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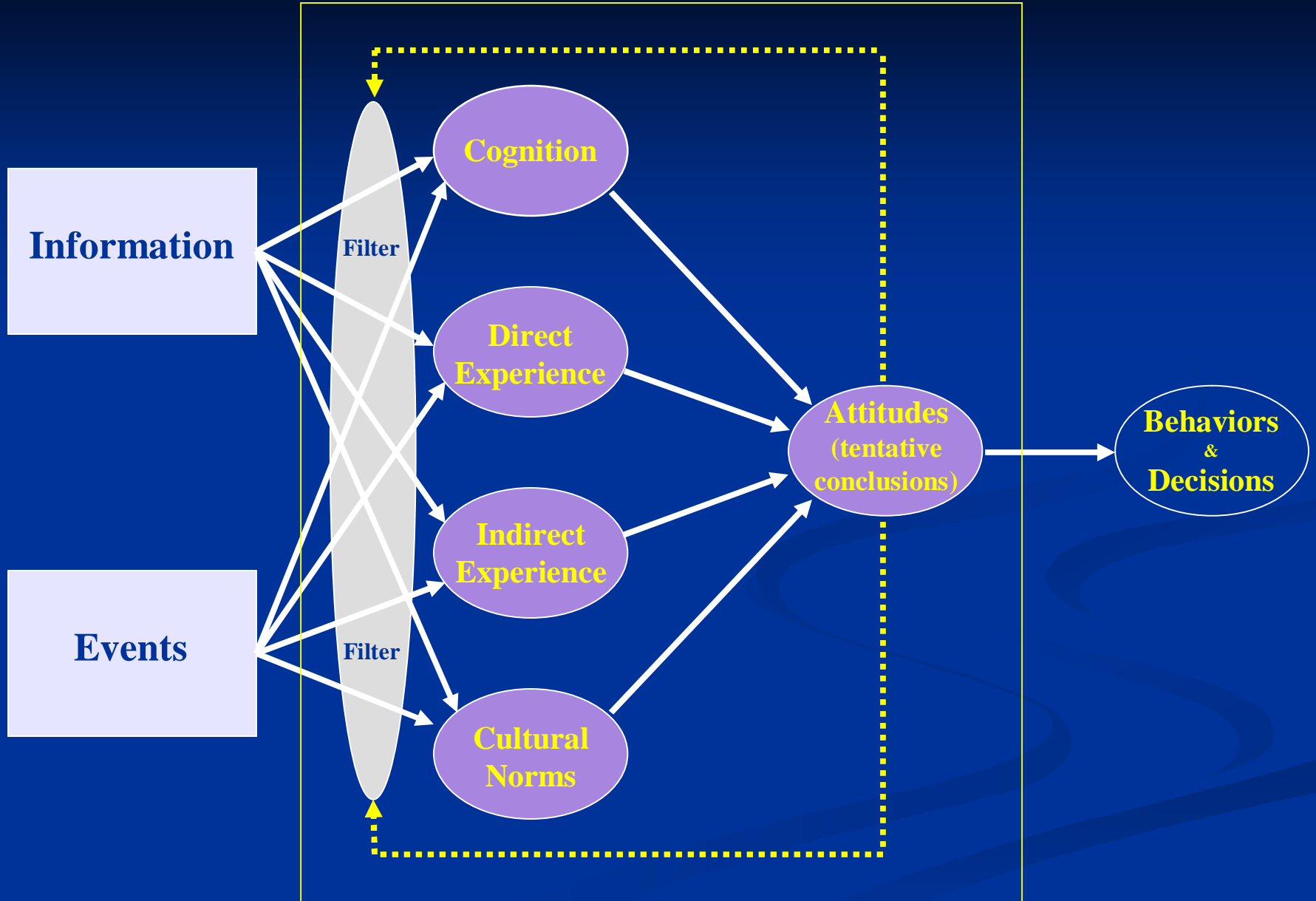
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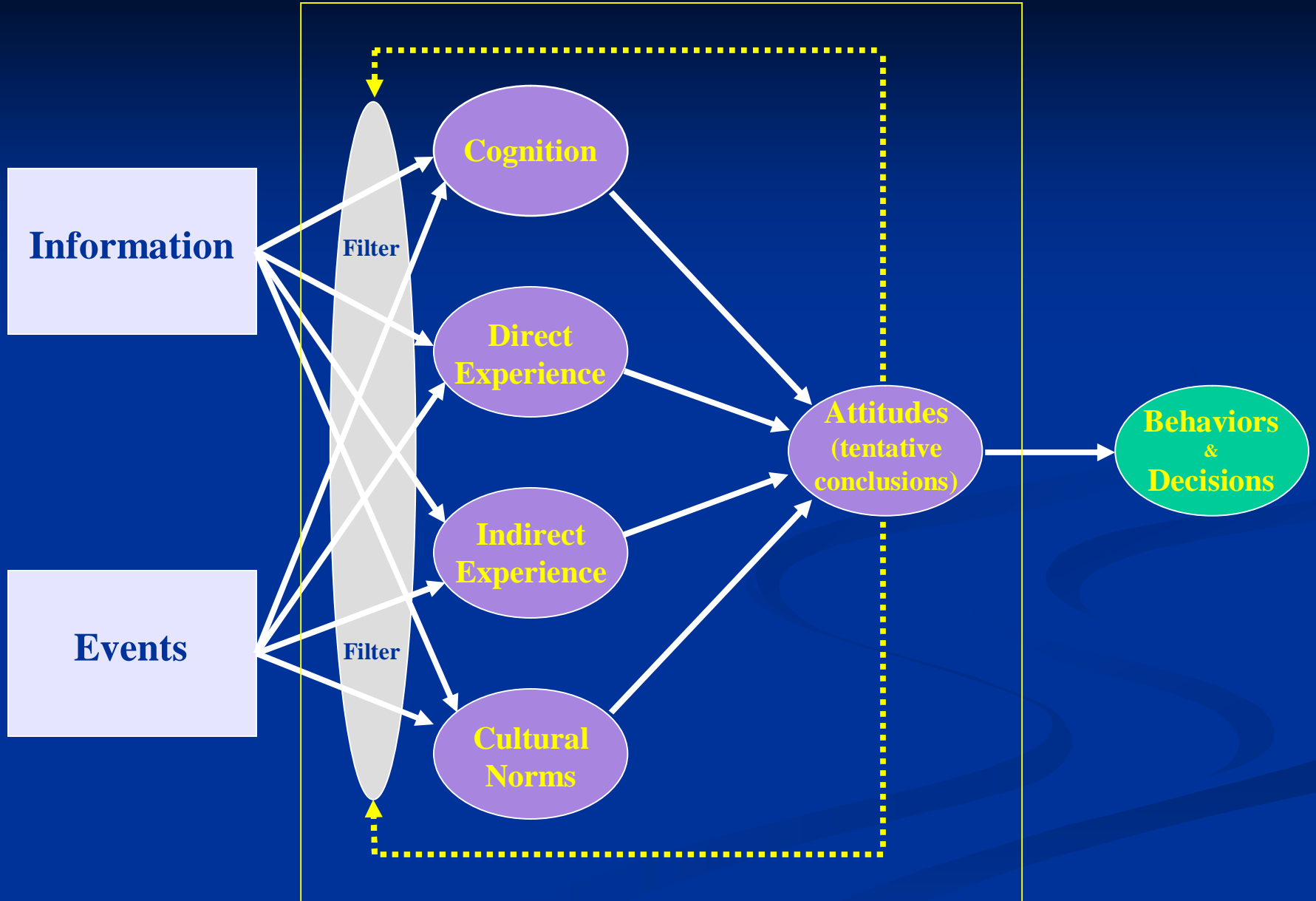
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Schema



Schema



To understand the operation of a schema in student and adult learning, it is useful to look at two examples.

- n Public understanding of antibiotics. Over the last 20 years, the percentage of adults who understand that antibiotics do not kill both viruses and bacteria has doubled. Most of this change can be attributed to learning during the adult years.**
- n Public understanding of nanotechnology. Few students or adults are exposed to information about science or technology at the nano level during formal schooling and must acquire whatever information they hold from informal sources.**

Public Understanding of an Antibiotic, 1988, 2005.

	Percent Correct		N	
	1988	2005	1988	2005
All Adults	26	54	2,041	1,720
Gender				
Female	28	54	1,084	893
Male	22	54	957	826
Age				
18-24 years	18	56	317	155
25-34 years	30	51	486	389
35-44 years	32	55	372	348
45-54 years	30	51	264	312
55-64 years	27	61	268	265
65 or more years	14	51	331	250
Education				
Less than high school	12	30	530	257
High school graduate	24	52	1,157	1,031
Baccalaureate	46	73	234	272
Graduate or professional degree	62	74	119	160

Cohort analysis of public understanding of antibiotics.

Respondent Age in 1988	Year					Respondent Age in 2005
	1988	1990	1995	1999	2005	
<18	--	--	--	38%	53%	24-33
18-26	26	30	44	48	54	34-43
27-36	34	36	47	56	52	44-53
37-46	40	40	49	51	60	54-63
47-56	33	32	34	44	59	64-73
57+	26	19	25	30	37	74+

Cohort analysis of public understanding of antibiotics.

Respondent Age in 1988	Year					Respondent Age in 2005
	1988	1990	1995	1999	2005	
Less than high school						
<18	--	--	--	22	18	24-33
18-26	10	19	36	24	20	34-43
27-36	22	16	17	13	21	44-53
37-46	8	17	33	29	32	54-63
47-56	21	9	10	33	61	64-73
57+	11	11	9	14	20	74+
Baccalaureate						
<18	--	--	--	50	72	24-33
18-26	42	47	61	69	73	34-43
27-36	49	52	57	70	70	44-53
37-46	54	52	69	72	78	54-63
47-56	54	54	--	--	--	64-73
57+	33	39	50	--	--	74+

In a national online survey of American adults in 2004 (using the Knowledge Networks adult panel), respondents were asked a series of open-ended questions about a set of basic scientific and technical constructs, including nanotechnology.

- **Each respondent was asked: “When you see or read the term nanotechnology in a newspaper or magazine, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?”**
- **All respondents who indicated that they had a clear understanding or a general sense of the term were then asked to provide an open-ended explanation of “nanotechnology.”**
- **Similar open-ended questions were asked about the terms molecule, neuron, and stem cell.**

Looking first at individual self-assessments of nanotechnology understanding:

- 9% of adults claimed to have a clear understanding of the meaning of nanotechnology.**
- 19% of adults said that they had a general sense of the meaning of nanotechnology.**
- 72% indicated that they had little or no understanding of the term.**

Adult Self-assessed Understanding of Molecule and Nanotechnology, 2004.

Understanding of Molecule	Understanding of nanotechnology			N
	Little	General	Clear	
Little understanding	95%	4%	1%	673
General sense	74	24	2	786
Clear understanding	37	32	31	492
All adults	72	19	9	1,951

Gamma = .78; sig. = .000.

Adult Understanding (Coded) of Molecule and Nanotechnology, 2004.

Understanding of Molecule	Understanding of nanotechnology			N
	None	Partial	Correct	
None or incorrect	91%	8%	1%	1,348
Partial	68	25	7	279
Correct	45	33	22	360
All adults	79	15	6	1,987
Gamma = .73; sig. = .000.				

Relationship (coded) by level of education.

Understanding of Molecule	Understanding of nanotechnology			N
	None	Partial	Correct	
Less than high school				
None or incorrect	97%	3%	0%	275
Partial	57	38	5	21
Correct	67	28	6	18
All adults	92	7	1	314
Gamma = .85; sig. = .000.				
High school diploma				
None or incorrect	92%	7%	1%	870
Partial	73	22	5	156
Correct	50	26	24	164
All adults	83	12	5	1,190
Gamma = .72; sig. = .000.				
Baccalaureate				
None or incorrect	77%	19%	4%	202
Partial	63	27	10	103
Correct	37	41	22	178
All adults	59	29	12	483
Gamma = .54; sig. = .000.				

Relationship (coded) by number of college science courses.

Understanding of Molecule	Understanding of nanotechnology			N
	None	Partial	Correct	
No college science courses				
None or incorrect	94%	5%	1%	1,039
Partial	76	20	4	144
Correct	59	31	10	99
All adults	89	9	2	1,282
Gamma = .70; sig. = .000.				
1 to 3 college science courses				
None or incorrect	86%	14%	0%	189
Partial	65	28	7	81
Correct	48	33	19	122
All adults	70	23	7	392
Gamma = .60; sig. = .000.				
4 or more college science courses				
None or incorrect	72%	23%	5%	119
Partial	54	33	13	55
Correct	32	36	32	139
All adults	51	30	19	313
Gamma = .56; sig. = .000.				

Building on the basic model proposed by Sternberg and other cognitive psychologists, individuals who understand other basic constructs such as molecule, neuron, or stem cell should be able to locate and incorporate a new term such as nanotechnology into their science schemas than adults with less understanding of other constructs.

- **To examine this proposition, a simple index was constructed to count the number of other basic constructs (molecule, neuron, stem cell) that each individual was able to identify correctly in an open-ended format.**
- **The Index of Science Construct Understanding ranges from zero to three.**

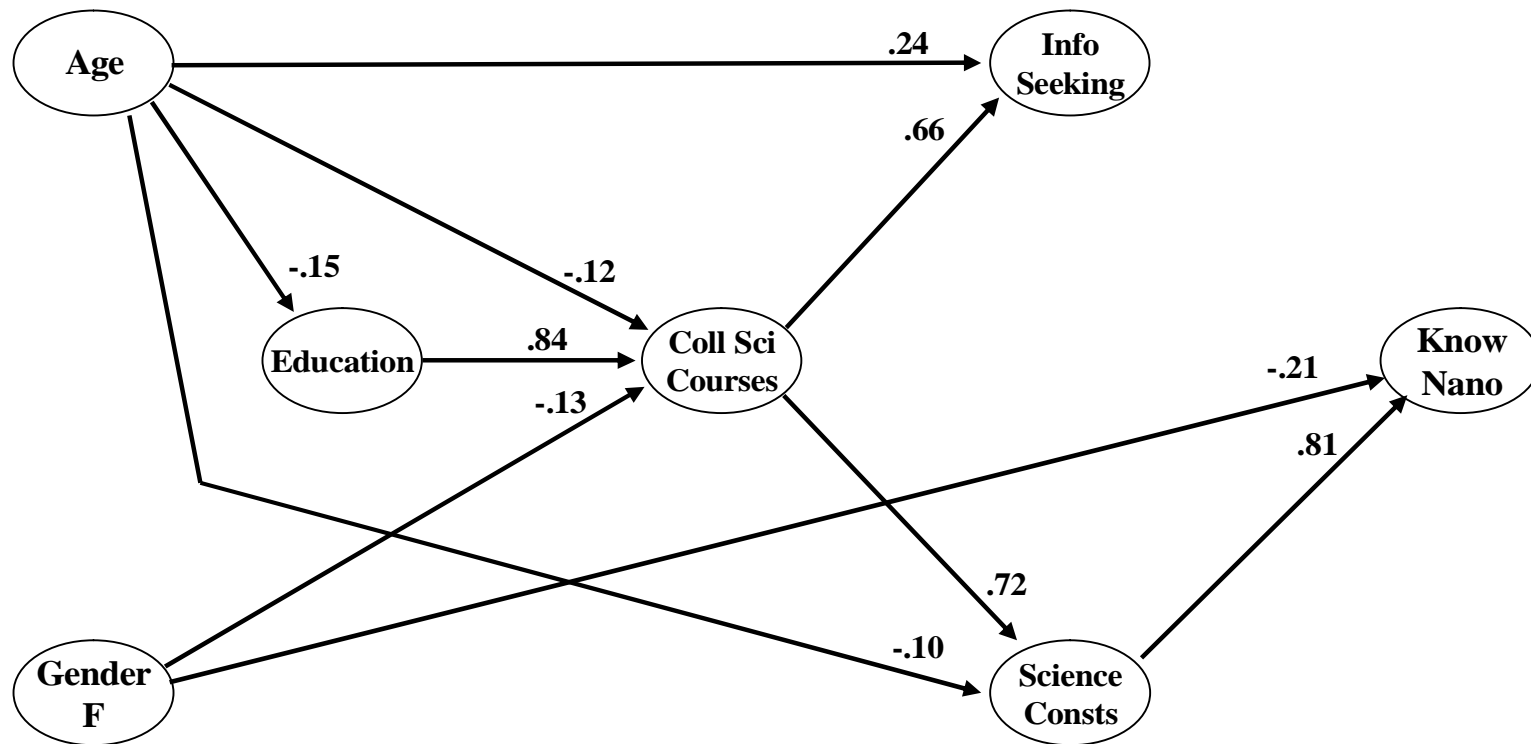
Relationship of Construct Understanding (Index) to Understanding of Nanotechnology

Understanding of Other Constructs	Understanding of nanotechnology			N
	None	Partial	Correct	
None	94%	5%	1%	1,098
One	73	23	4	513
Two or three	44	34	22	376
All adults	79	15	6	1,987
Gamma = .76; sig. = .000.				

To estimate the impact of each of several independent variables on each respondent's understanding of nanotechnology, a simple structural equation model was constructed.

- **The dependent or outcome variable is a dichotomous variable: the ability of a respondent to provide a correct open-ended explanation of nanotechnology.**
- **An Index of Science Information Acquisition was constructed and added to the model to test the proposition that adult understanding of nanotechnology comes primarily from media exposure rather than prior science construct understanding.**

A Path Model to Predict Adult Understanding of Nanotechnology



Total Effects of Variables in Model on Understanding.

Variables	Total Effect
Age	-.22
Gender (F)	-.28
Education	.49
College science courses	.59
Understanding of scientific constructs	.81
Information seeking behaviors	.00
$R^2 =$.73
Chi-squares = 107.6; degrees of freedom = 9; N = 1,987; Root Mean Square Error of Approximation (RMSEA) = .021; Upper limit of 90 th percentile confidence interval (RMSEA) = .036.	

This schema-based model of learning about science and technology emphasizes the necessity to think about learning:

- n as a continuous process that adds new information, sometimes replaces previous information, and combines cognitive understanding with experiences and attitudes to produce a general understanding and disposition toward any subject or object.**
- n as the development of retained information and understanding that can be recalled and used as needed in reacting to new issues or problems, or reaching conclusions about continuing issues or problems.**
- n as a process that is influenced by salience, necessity, and curiosity.**

