



Preference Elicitation

Advanced Decision Support Systems



Preference Elicitation

How does the recommender system learn about users' preferences?

- Knowledge-based: user characteristics + answer questions

- Content-based recommenders: assigning attribute weights

- Collaborative filtering: rating items

Are there better ways of doing this?

- Yes, and the best solution depends on the user!



Individual differences

User characteristics, decision strategies,
and interaction methods



Differences...

In most recommenders, the recommendations are tailored
but the interaction is the same for every user!

People also differ in how they make decisions!

They may need different ways of interacting with the
system



Differences...

On what characteristics do users differ?

E.g. experts vs. novices, distrusting vs. trusting, satisficers vs. maximizers

Do they use different decision strategies?

Think back to the decision-making lecture!

Can we tailor the system to these differences?

Which interaction methods support these strategies?



The system

Overview of the recommender system we used to study this



The system

Attribute weights w_a

8 Attributes a

Recommendations i

Rank by U_i ,
limit to top N

Attribute values $v_{i,a}$

$$\text{MAUT: } U_i = \sum w_a * v_{i,a}$$

Web Recommender System

www.besparingshulp.nl/exp.php?session=1e4a814989818f3a30d0225aba5f25ad

Indicate your preference

Attribute	Weight
less important	8%
less important	11%
less important	8%
less important	14%
less important	22%
less important	8%
less important	14%
less important	15%

Make a choice

Name	Initial effort	Continuous effort	Initial costs	Savings euro/year	Savings kWh/year	Return on investment	Env. effects	Comfort
Roof insulation			€ 3100.00	€ 299.00	1424 kWh	10 year	+	+
Laptop instead of a PC			€ 95.00	€ 31.50	150 kWh	3 year	+	+
Turn off PC when absent							+	+
Washing machine							+	+
Curtains/shutters at night							+	+
3 minutes less							+	+
Heat exchanger							+	+
Washing machine							+	+
Air-dry clothes							+	+
A++ Fridge/freezer combo			€ 180.00	€ 73.50	350 kWh	29 months	+	+
A+ Fridge/freezer combo			€ 110.00	€ 56.70	270 kWh	22 months	+	+

Show totals in ☒ euro ☐ kWh

You have been using the system for 1 minutes. When you press stop, you will be asked a few final questions, after which you can print your savings.

stop

This is what I want to do:

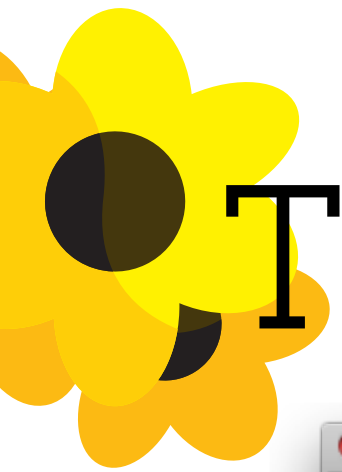
Enable PC energy management	€ 67.20
Install LED light bulbs	€ 121.20
Place heat exchangers on the air vents	€ 261.06
Shut down boiler in the summer	€ 59.85
This is what I will save per year:	€ 509.31

This is what I already do:

Double glazing	€ 302.00
Green energy	none
Cook on gas instead of electric	€ 75.00
I was already saving per year:	€ 377.00

This is what I don't want to do:

HR-E boiler	€ 320.00
LED light bulbs	€ 85.99



The Recommender System

Web Recommender System

www.besparingshulp.nl/exp.php?session=1e4a814989818f3a30d0225aba5f25ad

Indicate your preference

Here is a list of possible needs. Indicate how important they are for you. By clicking **multiple times** you can change your preference.

☐	☐	less important	8%	Little initial effort	more important	☐	☐
☐	☐	less important	11%	Little continuous effort	more important	☐	☐
☐	☐	less important	8%	Low initial costs	more important	☐	☐
☐	☐	less important	14%	Save more money	more important	☐	☐
☐	☐	less important	22%	Save more energy	more important	☐	☐
☐	☐	less important	8%	Quick return on investment	more important	☐	☐
☐	☐	less important	14%	Positive environmental effects	more important	☐	☐
☐	☐	less important	15%	High comfort	more important	☐	☐

Make a choice

Here are several **recommendations**; choose those energy-saving measures from this list which you want to do, or which you are already doing.

Name	Initial effort	Continuous effort	Initial costs	Savings euro/year	Savings kWh/year	Return on investment	Env. effects	Comfort
Roof ins.			€ 3100.00	€ 299.00	1424 kWh	10 year		
Laptop inster			€ 95.00	€ 31.50	150 kWh	3 year		
Turn off PC			none	€ 96.28	458 kWh	direct		
Heap laundry			none	€ 57.75	275 kWh	direct		
Close curtains/shutters at night			none	€ 57.47	639 kWh	direct		
Shower 3 minutes less			none	€ 50.00	450 kWh	direct		
Boiler-heated dryer			€ 650.00	€ 100.00	370 kWh	7 year		
Air-dry clothes			none	€ 60.90	290 kWh	direct		
A++ Fridge/freezer combo			€ 180.00	€ 73.50	350 kWh	29 months		
A+ Fridge/freezer combo			€ 110.00	€ 56.70	270 kWh	22 months		

Your savings

Here are your selected savings!

Show totals in ☒ euro ☐ kWh

You have been using the system for 1 minutes. When you press stop, you will be asked a few final questions, after which you can print your savings.

stop

This is what I want to do:

Enable PC energy management	€ 67.20
Install LED light bulbs	€ 121.20
Place heat exchangers on the air vents	€ 261.06
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This is what I will save per year:	€ 509.31

This is what I already do:

Double glazing	€ 302.00
Green energy	none
Cook on gas instead of electric	€ 75.00
I was already saving per year:	€ 377.00

This is what I don't want to do:

HR-E boiler	€ 320.00
Install CFL light bulbs	€ 85.99

Click!



The system

Web Recommender System

www.besparingshulp.nl/exp.php?session=1e4a814989818f3a30d0225aba5f25ad

Indicate your preferences

Here is a list of possible needs. Indicate how important they are for you. By clicking multiple times you can change your preference.

Roof insulation

Initial effort: [graph]
Continuous effort: [graph]
Initial costs: € 3100.00
Savings euro/year: € 299.00
Savings kWh/year: 1424 kWh
Return on investment: 10 year
Environmental effects: [graph]
Comfort: [graph]

Heat rises, so it is a good idea to insulate at the point where it usually escapes. Installing roof insulation is a good way to do this. For houses with a pointed roof, this is an easy procedure.

Select what you want to do with this measure...

Make a choice

Here are several recommendations. Choose those energy-saving measures which you already do or don't want to do.

Choose what to do

Selected measures

This is what I want to do:

Enable PC energy management	€ 67.20
Install LED light bulbs	€ 121.20
Place heat exchangers on the air vents	€ 261.06
Shut down boiler in the summer	€ 59.85
This is what I will save per year:	€ 509.31

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HR-E boiler	€ 320.00
Install CFL light bulbs	€ 85.99

stop

Things I already do or don't want to do



Attribute-based PE

The recommender needs to learn attribute weights

This is called Preference Elicitation (PE)

Most basic method: Attribute-based PE

		less important	8%	Little initial effort	more important			
		less important	11%	Little continuous effort	more important			
		less important	8%	Low initial costs	more important			
		less important	14%	Save more money	more important			
		less important	22%	Save more energy	more important			
		less important	8%	Quick return on investment	more important			
		less important	14%	Positive environmental effects	more important			
		less important	15%	High comfort	more important			

Rooted in “weighted adding” a complex compensatory decision strategy

Not the best for domain novices... Can we do better?



Case-based PE

Increase attribute weights one-by-one; find exemplary items

Users evaluate items (pos/neg); this translates into a (higher/lower) attribute weight

			I don't like this	Turn PC off when not present	I like this		
			I don't like this	Replace lights that are always dimmed	I like this		
			I don't like this	Lower the thermostat by 1 degree C	I like this		
			I don't like this	Install a heat exchanger on your air vents	I like this		
			I don't like this	Extinguish your boiler's pilot light in the summer	I like this		
			I don't like this	Wash clothes at a lower temperature	I like this		
			I don't like this	Turn off the screen of your PC	I like this		
			I don't like this	Cook on a gas stove instead of electric	I like this		

Note: No attribute knowledge required, but may be less transparent because it does not display the weights

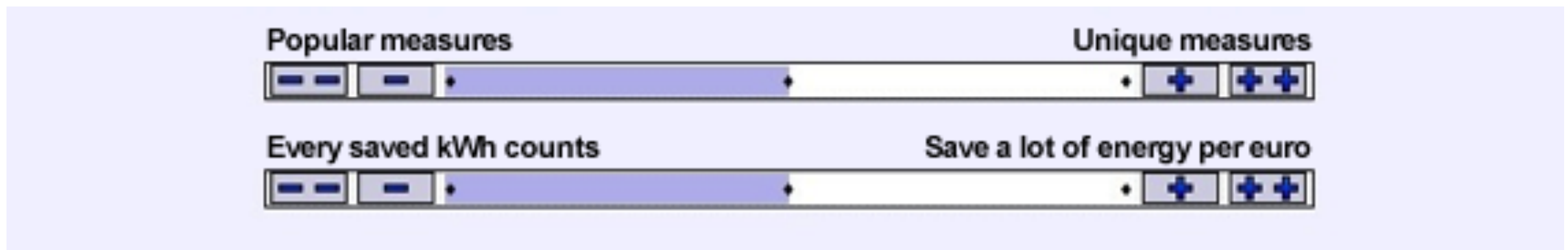


Needs-based PE

Users express their preferences in terms of needs

Needs are based on latent product attributes

cf. Matrix Factorization



Note: Overcomes the problem of translating needs into attribute values, but may be too simplistic



Implicit PE

Attribute weights are automatically inferred from user's browsing behavior.

based on attribute values of inspected/selected/discarded recommendations

Similar to implicit feedback in collaborative filtering

Less input required, but may cause narrowing

Pariser's positive reinforcement loop!



Hybrid PE

A combination of implicit PE and attribute-based PE

Combines the convenience of Implicit PE with the ability to monitor and control the attribute weights manually

Note: Can overcome narrowing, but adds some complexity

Moves away from the simplicity of implicit PE



Baseline methods

TopN: the 10 most popular measures

Not personalized, virtually no interaction

Get more recommendations by classifying measures

Sort: sort the measures by any attribute

Implements the lexicographic strategy:

1. Select the most important attribute
2. Choose the item with the highest value on this attribute

Users can (re-)sort by clicking on table headers



Strategy

Does the best PE method depend on personal characteristics?

1. Randomly assign one of these PE methods to a user
2. Measure perceptions and user experience
3. Measure personal characteristics
4. Plot the results



Domain knowledge

Do the results differ between experts and novices?



Domain Knowledge

Energy-saving experts have more knowledge about the attributes of energy-saving measures

Easier to translate needs into attribute weights and make trade-offs between them

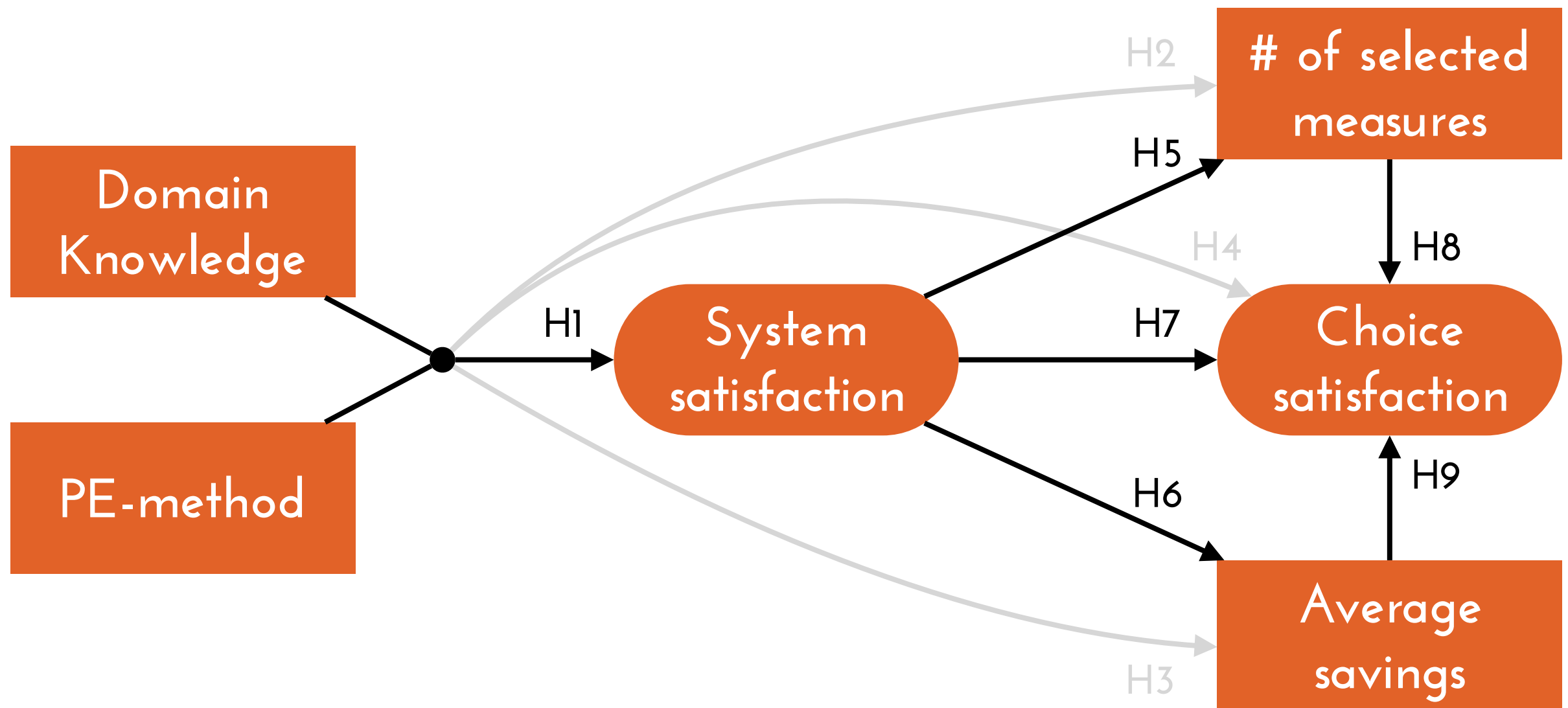
Novices lack the knowledge required to understand the impact of the attributes (Hutton and Klein 1999)

May not know how to express their preferences in terms of attributes

Experts and novices may prefer different PE-methods!



Hypotheses





Measurement

	Study 1	Study 2	Study 3	Study 4
I know the energy consumption of all devices in my household	0.826	0.791	0.641	0.627
I understand difference between different types of energy-saving measures	0.863	0.766	0.764	0.762
I know energy-saving measures that most others haven't even heard of	0.748	0.789	0.791	0.699
I know which energy-saving measures are useful to implement	0.851	0.717	0.753	0.783
I am able to choose the right energy-saving measures	0.776	not tested	0.858	0.874
I sometimes doubt whether I chose good energy-saving measures	-	not tested	-	-
I don't understand most energy-saving measures	-	not tested	-0.725	-



Interaction

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Turn off PC when absent			none	€ 96.28	458 kWh	direct		
Heap laundry			none	€ 57.75	275 kWh	direct		
Close curtains/shutters at night			none	€ 57.47	639 kWh	direct		
Shower 3 minutes less			none	€ 50.00	450 kWh	direct		
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Your savings

Here are your selected savings!

Show totals in ☒ euro ☐ kWh

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stop

This is what I want to do:

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Install LED light bulbs	€ 121.20
Place heat exchangers on the air vents	€ 261.06
Shut down boiler in the summer	€ 59.85
This is what I will save per year:	€ 509.31

This is what I already do:

Double glazing	€ 302.00
Green energy	none
Cook on gas instead of electric	€ 75.00
I was already saving per year:	€ 377.00

This is what I don't want to do:

HR-E boiler	€ 320.00
Install CFL light bulbs	€ 85.99



Track Behaviors

We tracked the energy-saving measures users selected
("I want to do this")

Number of measures (log-transformed)

Average savings (in kWh, log-transformed)



System satisfaction

	Study 1	Study 2	Study 3	Study 4
The system made me more energy-conscious	-	-	0.658	0.811
The system restricted my decision freedom	-	-	-	-
I would use the system more often if possible	0.888	0.856	0.842	0.864
I make better choices with the system	0.738	0.703	0.806	0.772
The system was useless	-0.771	-0.803	-0.763	-0.881
I would recommend the system to others	0.853	0.905	0.836	0.921



Choice Satisfaction

	Study 1	Study 2	Study 3	Study 4
I like the measures I've chosen	0.750	0.697	0.707	0.823
I think I chose the best measures from the list	0.788	0.687	0.789	-
The chosen measures exactly fit my preference	0.577	0.820	0.769	0.697
How many measures will you implement?	-	-	0.664	0.810



Study 1

Online lab study

- 90 paid pps (66M, 24F, mean age: 36.0)
- Pps had to interact for at least 10 minutes

2 PE-methods

- Attribute-based PE
- Case-based PE

less important	10%	Initial effort	more important
less important	13%	Continuous effort	more important
less important	10%	Initial costs	more important
less important	24%	Savings euro/year	more important
less important	10%	Savings kWh/year	more important
less important	14%	Return on investment	more important
less important	10%	Environmental effects	more important
less important	10%	Comfort	more important

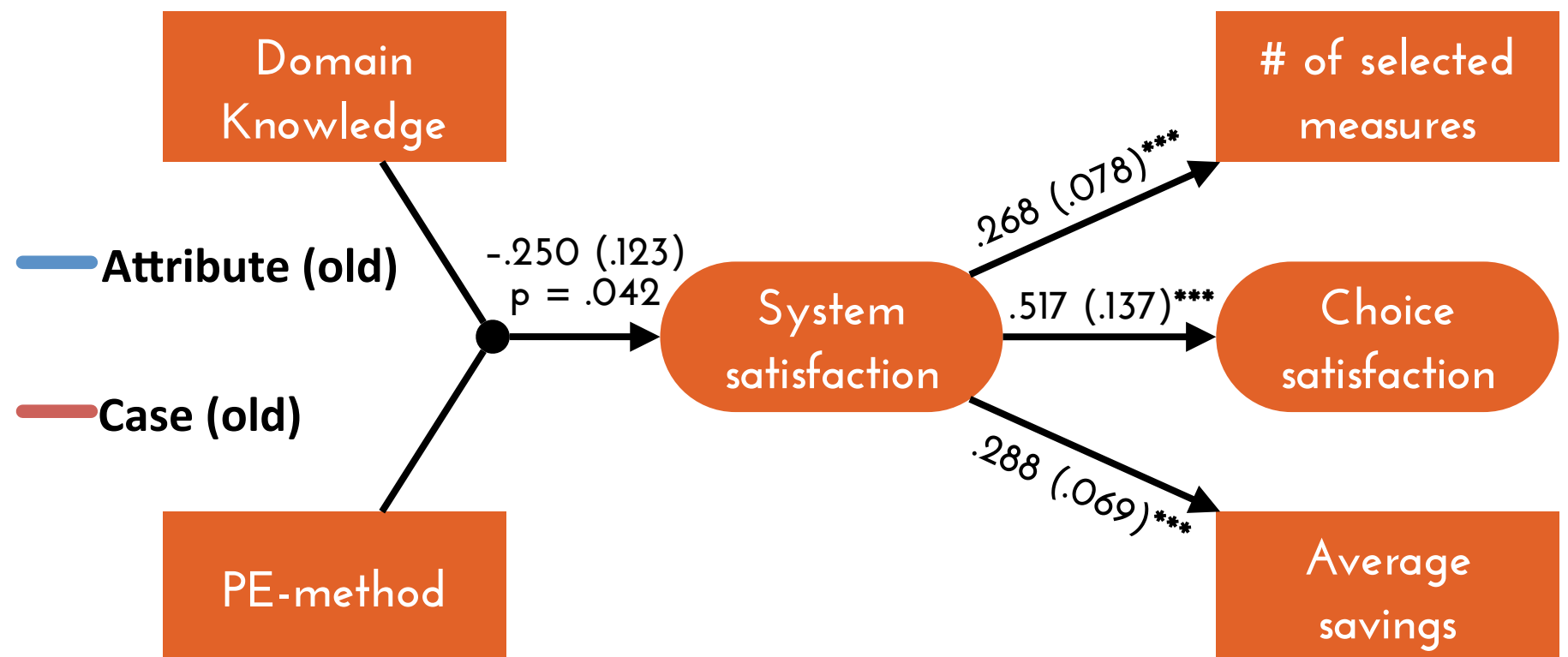
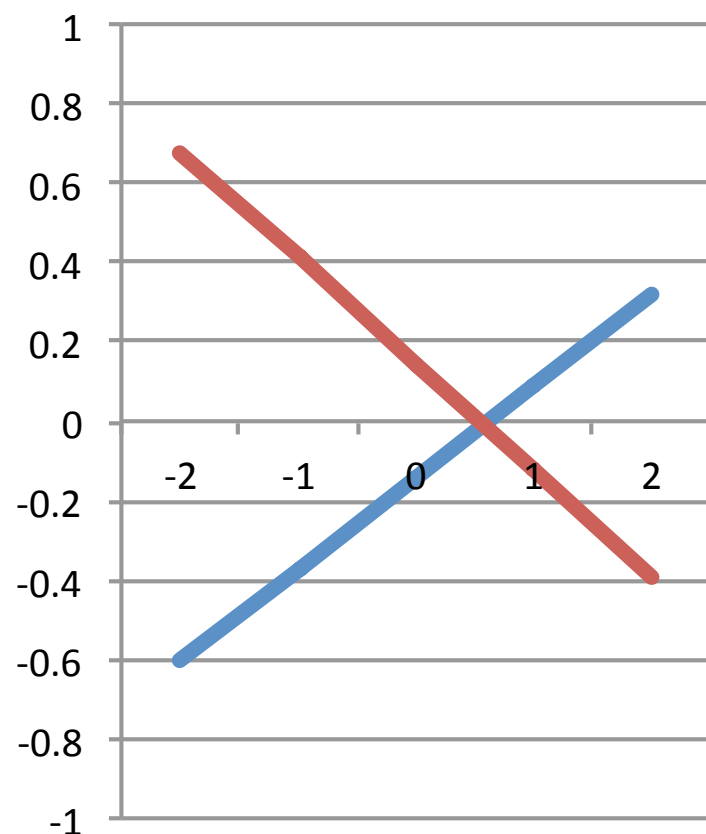
		Name	Initial effort	Continuous effort	Initial costs	Savings euro/year	Savings kWh/year	Return on investment	Environ. effects	Comfort
I don't like this	I like this	Shower 3 minutes less			none	€ 50.00	450 kWh	directly		
I don't like this	I like this	Lower the thermostat by 1 degree C			none	€ 51.00	567 kWh	directly		
I don't like this	I like this	Set your boiler to 65 degrees C			none	€ 25.41	121 kWh	directly		
I don't like this	I like this	Hoard your laundry			none	€ 57.75	275 kWh	directly		
I don't like this	I like this	Extinguish your boiler's pilot light in the summer			none	€ 59.85	665 kWh	directly		
I don't like this	I like this	Switch to renewable energy			none	none	0 kWh	directly		
I don't like this	I like this	Tumble dry shirts briefly instead of ironing them			none	€ 12.75	56 kWh	directly		
I don't like this	I like this	Condensing boiler			€ 3500.00	€ 320.00	2500 kWh	11 years		



Study 1 – Results

Experts prefer Attribute-based PE, novices prefer Case-based PE

Effects on choice behavior and satisfaction are fully mediated by system-satisfaction





Fixed Some Usability Issues

 less important	10%	Initial effort	 more important
 less important	13%	Continuous effort	 more important
 less important	10%	Initial costs	 more important
 less important	24%	Savings euro/year	 more important
 less important	10%	Savings kWh/year	 more important
 less important	14%	Return on investment	 more important
 less important	10%	Environmental effects	 more important
 less important	10%	Comfort	 more important



	 less important	8%	Little initial effort	more important			
	 less important	11%	Little continuous effort	more important			
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	I don't like this	Tum PC off when not present	I like this	
	I don't like this	Replace lights that are always dimmed	I like this	
	I don't like this	Lower the thermostat by 1 degree C	I like this	
	I don't like this	Install a heat exchanger on your air vents	I like this	
	I don't like this	Extinguish your boiler's pilot light in the summer	I like this	
	I don't like this	Wash clothes at a lower temperature	I like this	
	I don't like this	Turn off the screen of your PC	I like this	
	I don't like this	Cook on a gas stove instead of electric	I like this	





Study 2

Online field trial

- 107 pps (77M, 30F, mean age: 42.8)
- Selected pps interacted for at least 3 minutes

2 PE-methods

- Attribute-based PE (new)
- Case-based PE (new)

		less important	8%	Little initial effort	more important		
		less important	11%	Little continuous effort	more important		
		less important	8%	Low initial costs	more important		
		less important	14%	Save more money	more important		
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		I don't like this	Turn PC off when not present	I like this		
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		I don't like this	Lower the thermostat by 1 degree C	I like this		
		I don't like this	Install a heat exchanger on your air vents	I like this		
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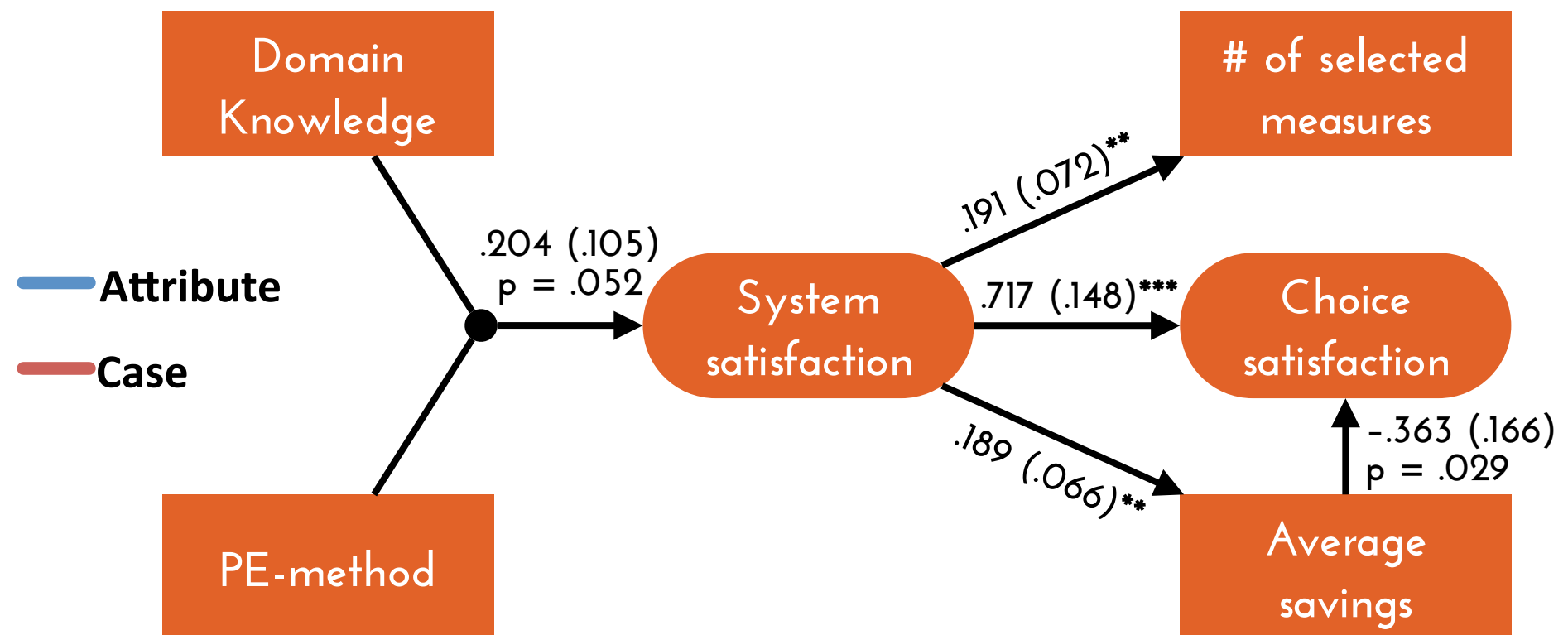
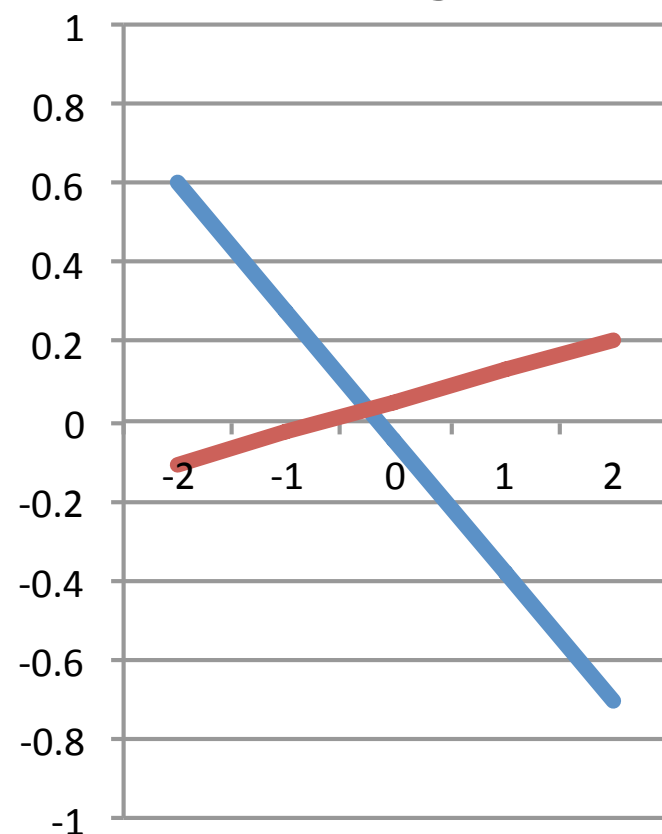


Study 2 – Results

Experts prefer Case-based PE, novices prefer Attribute-based PE

Opposite of Study 1!

Negative effect of average savings on choice satisfaction





Study 3

Online lab study

- 147 paid pps (79M, 68F, mean age: 40.0)
- Selected pps interacted for at least 2.5 minutes

3 PE-methods, 2 baselines

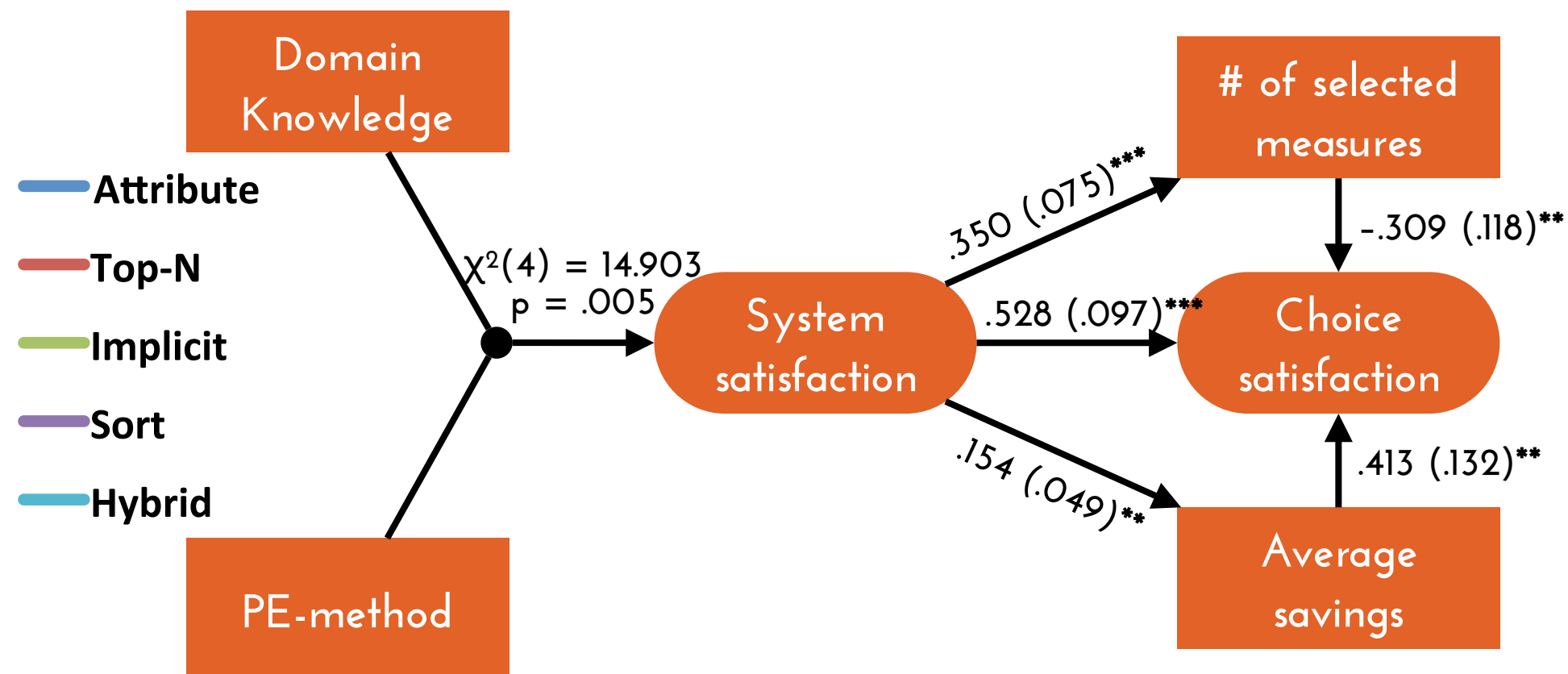
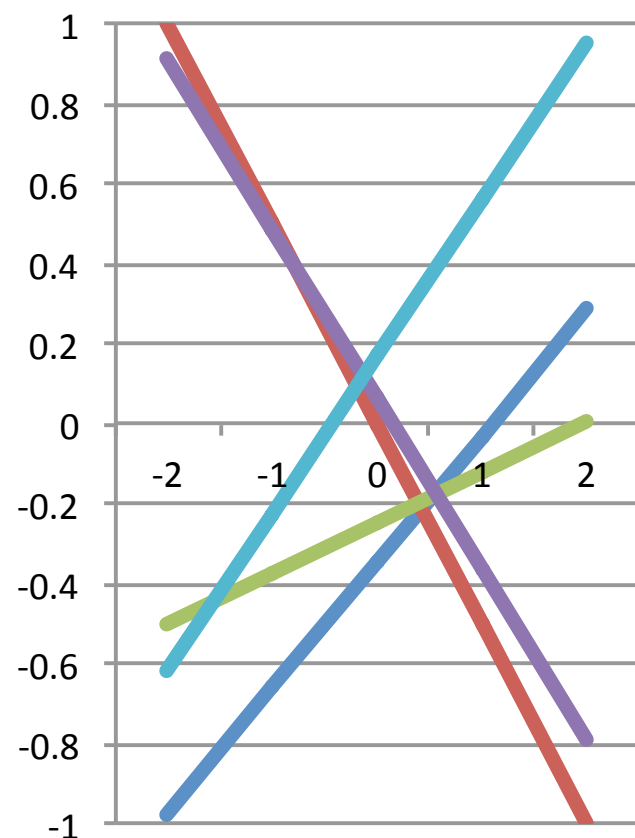
- Attribute-based PE (same as study 2)
- Implicit PE
- Hybrid PE
- Sort
- Top-N



Study 3 – Results

Experts prefer Attribute-based PE and Hybrid PE, novices prefer Top-N and Sort (baselines)

Negative effect of # of selected measures on choice satisfaction

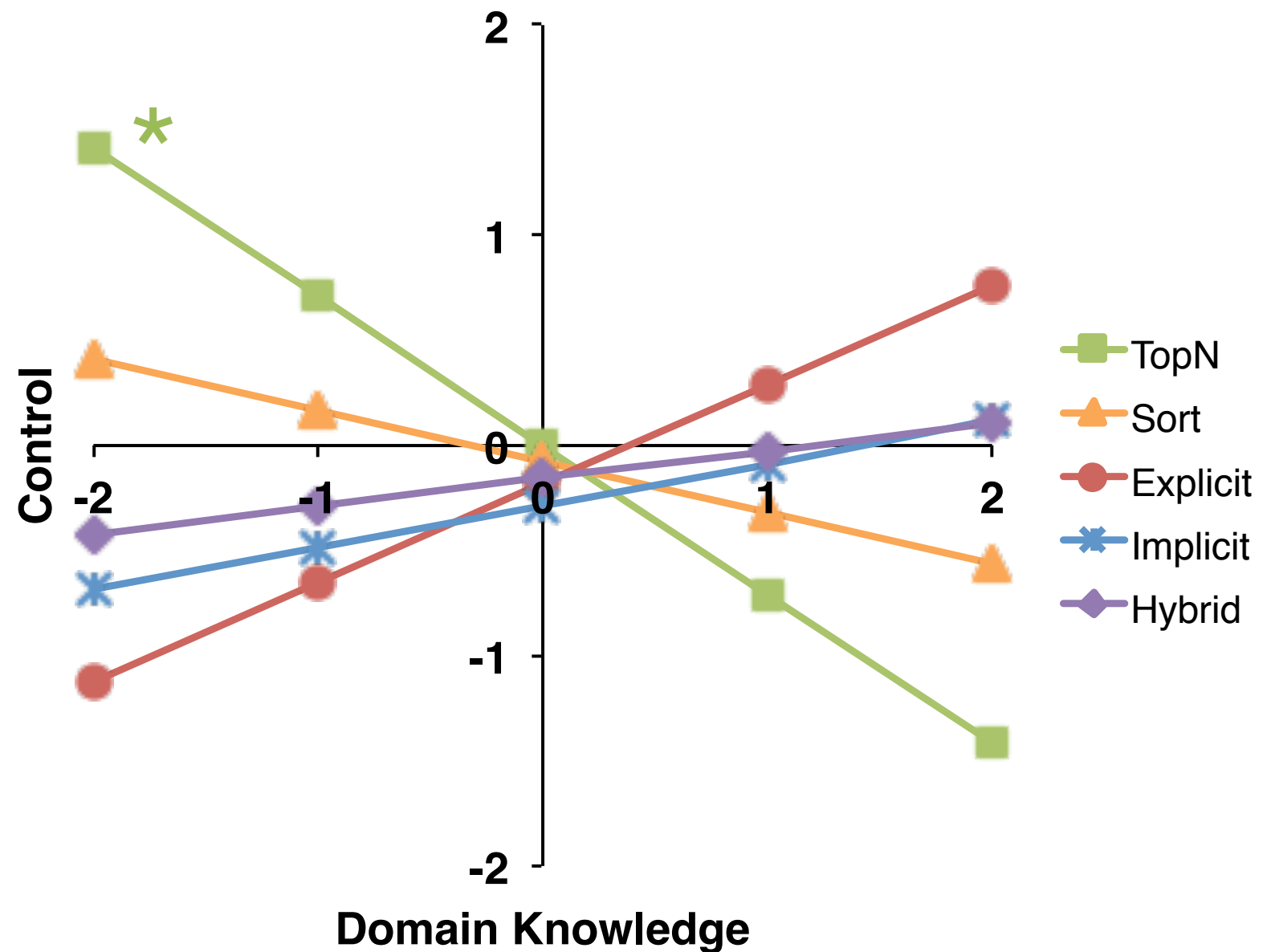




Study 3 – Results

Novices also perceive more **control** in TopN than experts, and find it much more **effective**

Sort 2nd place on most metrics

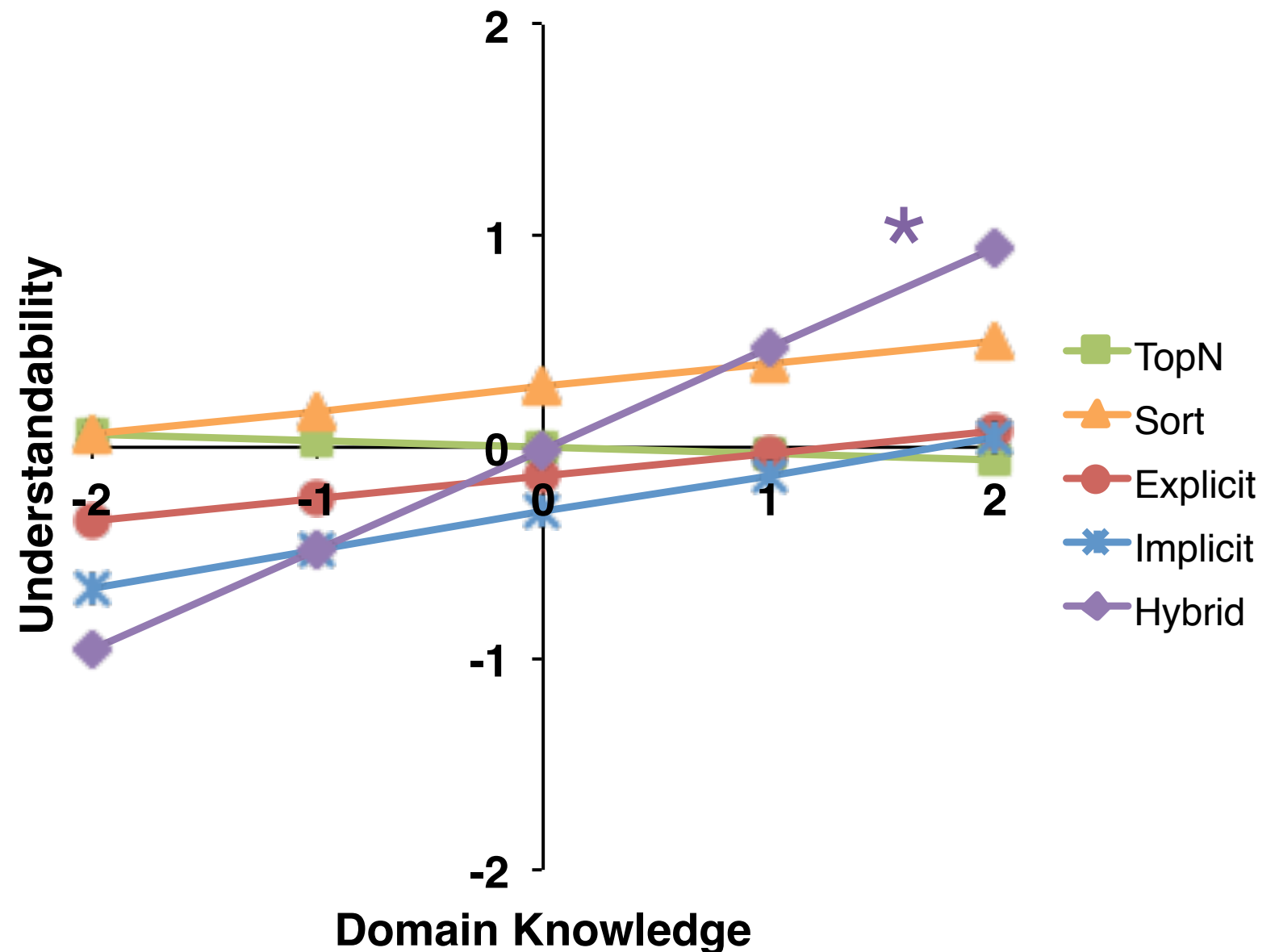




Study 3 – Results

Experts **understand** the Hybrid PE method the best, and find it much more **effective**

It combines the control of Explicit with the convenience of Implicit





Study 4

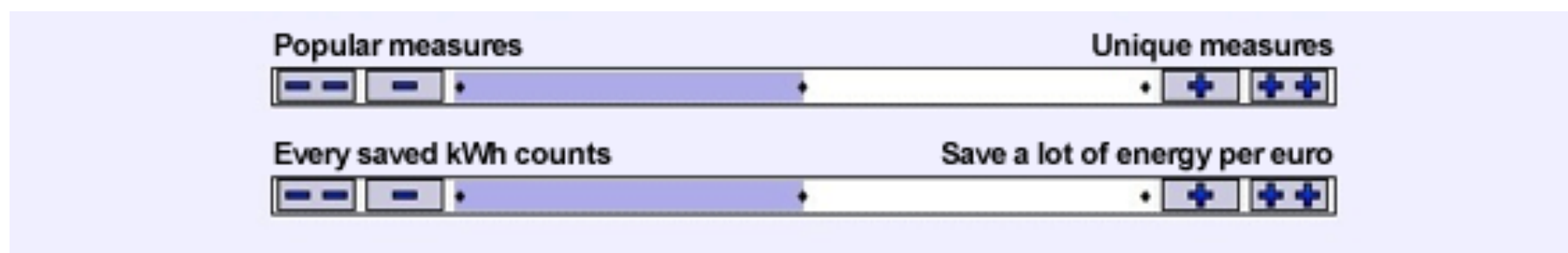
Online lab study

- 88 paid pps (44M, 44F, mean age: 28.0)
- Selected pps interacted for at least 2.5 minutes

2 PE-methods

- Attribute-based PE (same as study 2 and 3)
- Needs-based PE

		less important	8%	Little initial effort	more important			
		less important	11%	Little continuous effort	more important			
		less important	8%	Low initial costs	more important			
		less important	14%	Save more money	more important			
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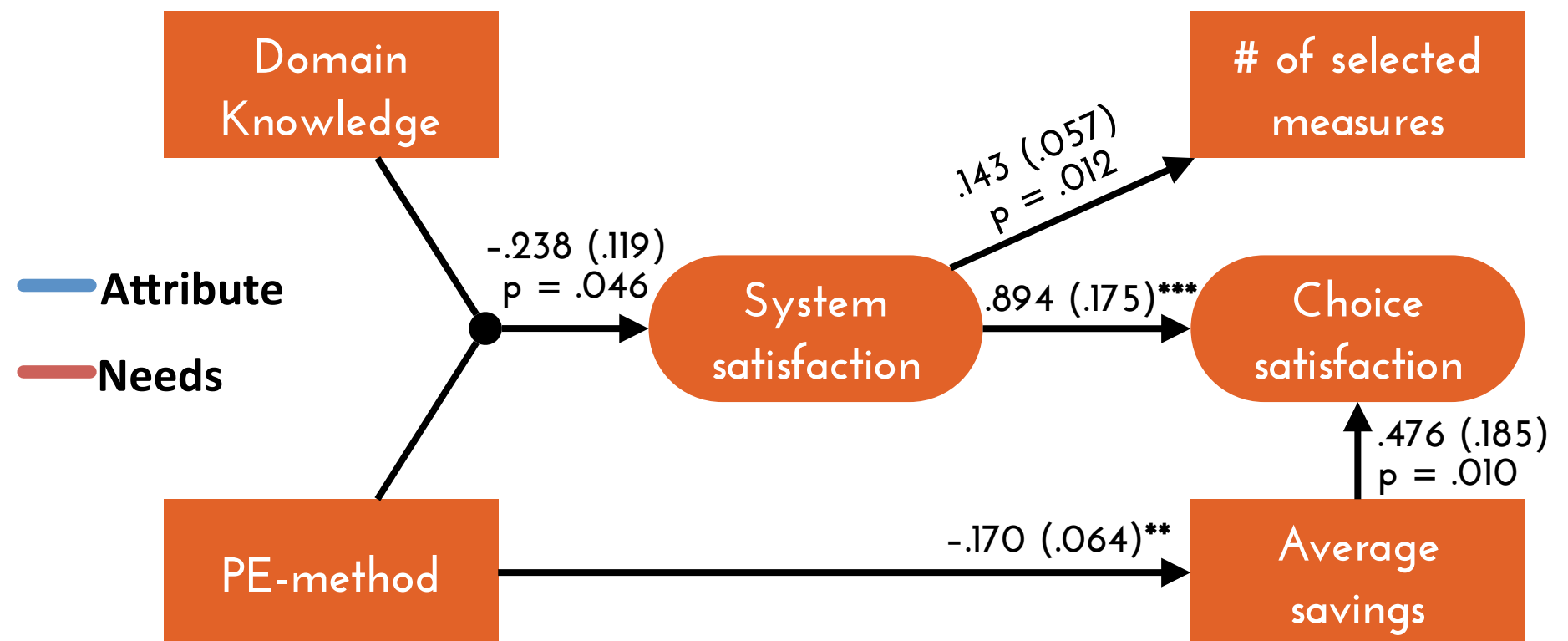
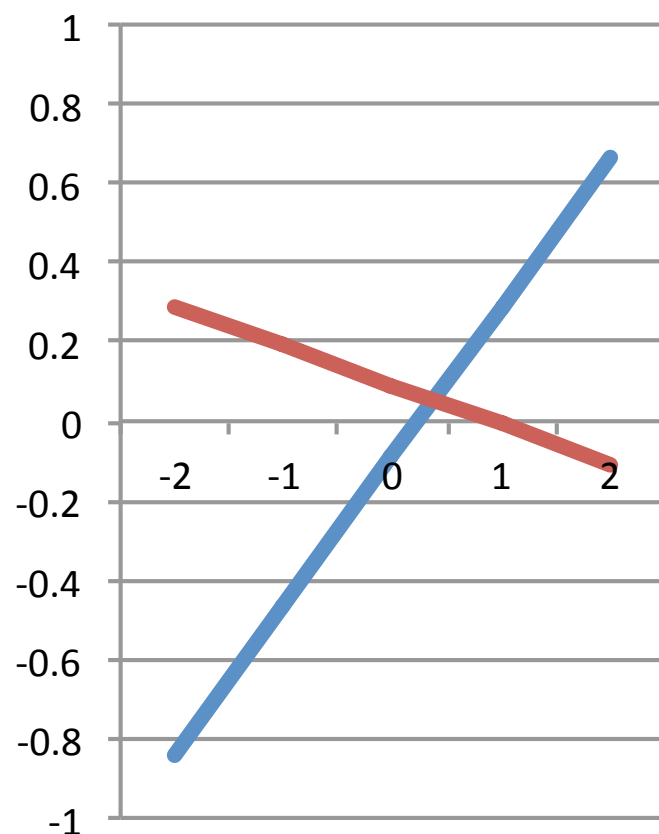




Study 4 – Results

Experts prefer Attribute-based PE, novices prefer Needs-based PE

Lower average savings with Needs-based PE





Summary of Results

Attribute-based and hybrid PE are better experts, Case-based and Needs-based PE are better for novices

Novices are also highly satisfied with the baseline systems!

A well-fitting PE method does not only have attitudinal but also behavioral consequences

Effect is fully mediated by system satisfaction



Study 2 is Inconsistent

The effect of PE-methods in study 2 is opposite to the same effects in the other studies!

Why the difference? No definite explanation...

Our best guess: study 2 was based on a convenience sample of field trial participants

Other studies had tighter experimental control



Other differences

Do the results differ on other characteristics as well?



Other differences

Trusting propensity

Trust is necessary to accept the recommendations

A lack of trust can cause reactance

Trust can be built over time, but users also have a trusting propensity

Distrusting users may not like Implicit

because they want a system that is either easy to understand (TopN, Sort) or easy to control (Explicit, Hybrid)

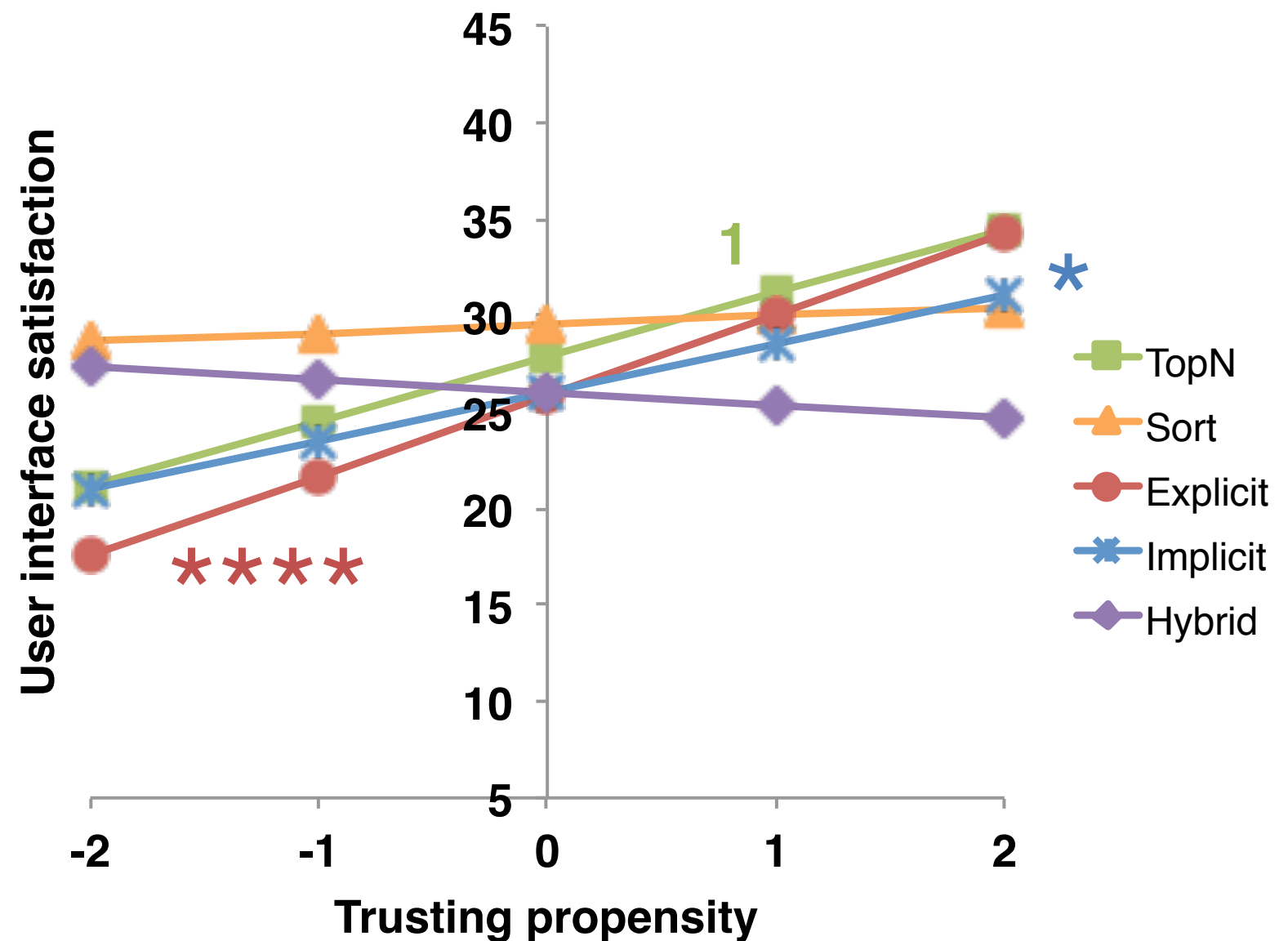


Study 3 – Results

Distrusting users
dislike Explicit, Implicit,
TopN

They are not
satisfied with the UI
They do not find
these systems
effective

Hybrid works best





Other differences

Choice persistence

Satisficers may like Implicit

The system updates the recommendations to provide similar items as soon as the user selects the first item

Maximizers may like Implicit or TopN

They usually engage in more counterfactual thinking, and anticipate more post-decision regret

This is aggravated in systems with tradeoffs (Sort, Explicit, Hybrid)

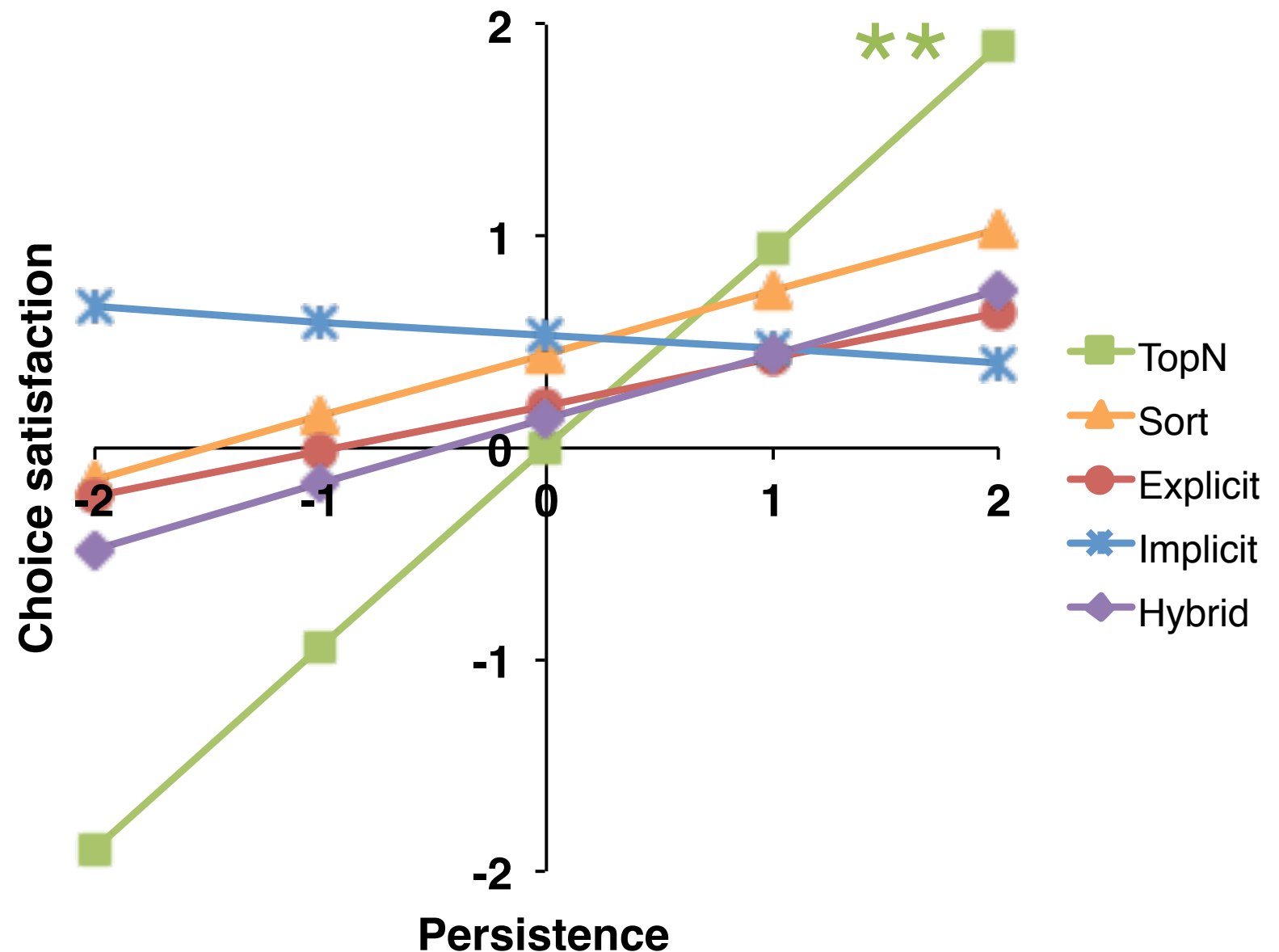


Study 3 – Results

Maximizers are more satisfied with their choices!

Maximizers like their choices in TopN

Satisficers like their choices in Implicit*





Conclusions

Implications for real-world recommender systems



Conclusions

Some reservations...

Small sample of users

28-33 participants per condition; low power

Domain encourages multiple decisions; dampens the effects

Results pertain to attribute-based systems

Does not necessarily apply to collaborative filtering



Conclusions

Hybrid is better than Explicit and Implicit

- For experts: tweak preferences: convenience and control

- For distrusting users: negative reactions to other systems

However, TopN may be better in some cases

- For novices: no knowledge to exploit the benefits

- For maximizers: no tradeoffs



Conclusions

Can we combine TopN and Hybrid?

Spatially separate them

In different sections of the interface

Temporally separate them

Start with the TopN, carefully introduce implicit recommendations, then introduce explicit controls

Assign the correct method to each user

Discover the user's characteristics, then tailor the interface to their specific needs



Conclusions

To each his own!

The best interaction method depends on user characteristics

Taking these into account may result in significantly better recommender systems