Modelling users' experience in human-computer interaction

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Outline

- User-experience (UX) and UX-modelling
- Models in human-computer interaction (HCI)
- Flexibility in UX-modelling
- Direction of causality of UX-modelling
- Empirical studies of UX-modelling
- Cognitive-experiential UX-modelling
- UX from an inference perspective
- Engineering approach to support HCI design
- Conclusions

User-experience (UX)

- "Users' judgement of product quality arising from their experience of interaction, and the product qualities which engender effective use and pleasure" (Sutcliffe, 2010)
- Interactive products do not only deliver functional benefits, they promote experiences too
- Users' intention to (re)live positive experiences is an important driver of technology use
- Instrumental and non-instrumental factors in UX (Thüring & Mahlke, 2007)
  - Usability may strongly contribute to negative experiences, if it does not reach a satisfactory level expected by users
  - However, in order to achieve positive experiences, high levels of non-instrumental factors (e.g. positive affect) are needed
- UX models – determinants of positive experiences

The importance of models in HCI

- Models that represent HCI knowledge are useful to
  - summarize data,
  - formalise relationships between variables and
  - make predictions,
  - *even if* or *precisely because* they possess a degree of *incompleteness* and *falseness*
- HCI models
  - can have *theoretical* and *practical* value
  - as long as they fit data well, and
  - make theoretical and practical sense,
  - without actually being entirely ‘truthful’ in their description of
  - a particular phenomenon or process

Important: flexibility in UX-modelling

- Flexibility in modelling is essential:
  - to select or develop UX models
  - based on outcome variables that are of interest
  - in terms of explanation or prediction,
  - instead of using a single 'one-size-fits-all' approach
- Outcome variables
  - indicators of success of a particular product
  - e.g. satisfaction or overall evaluation of UX
  - derived from
    - defined user-requirements (e.g. health improvement) or
    - marketing objectives (e.g. satisfied customers)
    - psychological theory (e.g. Sheldon, 2011)

Flexibility in UX-modelling (2)

- After UX has been measured, establish
  - to which extent requirements or objectives of the product have been met and
  - which other variables mostly contribute to explaining variance in the outcomes
  - as a basis for potential product improvement
- Products that share the same outcome variables
  - may share the same or similar models,
  - thereby facilitating potential (partial) re-use UX models for new products and
  - generalization of models

Imagine you want to enhance your voice-over-calls with a high-definition image. By coincidence, a local shop makes an exceptional offer (in terms of "value for money") of a multifunctional ("all-singing-all-dancing") webcam. Will you accept? The problem is to predict whether or to what extent the product would meet your needs. As you have no hands-on experience, you visit the shop to see for yourself what the product looks like in reality and to get further information from the helpful staff. However, you are not allowed to open the attractive transparent box in which the seductive product patiently awaits your expenditure. You simply cannot try the product before buying it. Therefore, in effect, you try to "guess" – or infer – the product’s reliability, usefulness and ease of use from the specific pieces of information that you find relevant.

Direction of causality in UX-modelling

- Specific-to-general inference/induction
- General-to-specific inference/deduction

Specific-to-general inference

- Overall assessments or attitudes are ‘built’ from the careful consideration, weighting and integration of specific attributes (e.g. usability, aesthetics)
- UX models related to computational, multi-attribute theories of decision-making
- Examples
    - UX model (Hassenzahl, 2003, 2004)
    - Components-of-UX model (Thüring & Mahlke, 2007)
    - Environmental-psychology model of UX (Porat &Tractinsky, 2012)
    - Also van Schaik and Ling (2008, 2011)
- However, should not be taken as the major or even the only inference process!

General-to-specific inference

- Related to non-computational approach to decision-making
- Supported by wealth of evidence (Gigerenzer & Gaissmaier, 2011)
- People use relatively simple strategies
- People infer momentarily hard-to-assess product attributes, even when information is absent or limited
- Inference rules, based on lay theory
- Example: Hassenzahl and Monk’s (2010) inference model

General-to-specific inference

- Example 1: price-quality rule
- Example 2: halo effect (“I like it, it must be good on all attributes”),
    - so potentially incorrect model specification from results if inductive inference is assumed
- Crucial are (1) notion of inference and (2) careful consideration of how assessments are potentially made in different situations
- No theoretical justification without these

“I can never think and play at the same time. It’s emotionally impossible.”

– From *The New Tristano*
(Lennie Tristano, 1962)

UX goes cognitive-experiential

- There is a growing feeling of unease that user-experience - UX - may have thrown out the baby (cognitive task performance) with the bathwater (usability)
- This is inadvisable, as - perhaps surprisingly - research has demonstrated that experiential factors such as aesthetics can enhance task performance (Moshagen, Musch & Göritz, 2009; Sonderegger & Sauer, 2010)
- So, this research makes the case for a cognitive-experiential approach to modelling UX
- In the process, an explanation is proposed for why Norman's principles of good design can be effective

The problem

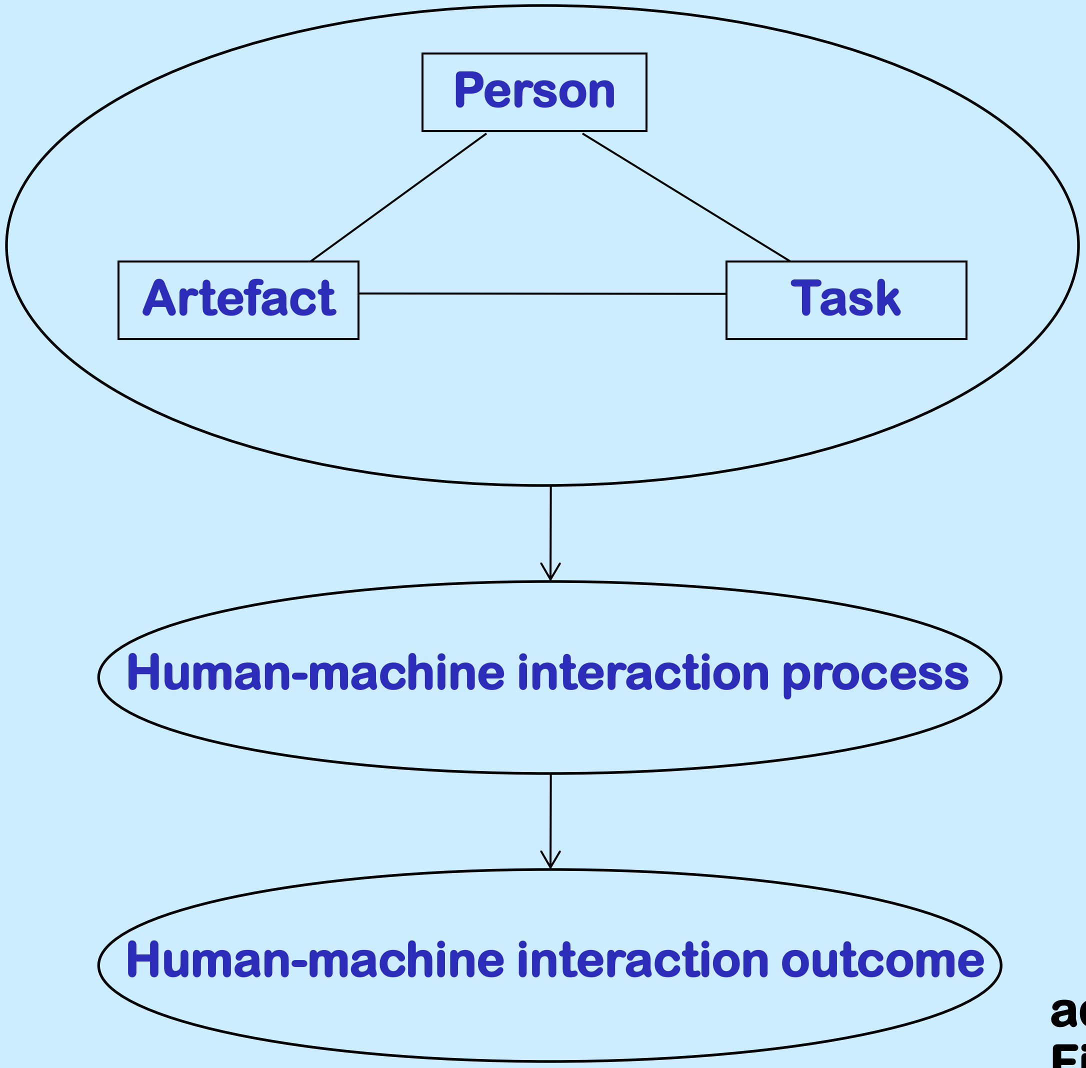
An exclusive focus on usability is not sufficient to account for users' task performance and experience

But an exclusive focus on experience is not sufficient either!

A proposed solution

Cognitive-experiential modelling of human-computer interaction

Research framework



adapted from Finneran and Zhang (2003)

The influence of the experiential

- Enhanced aesthetics increases task performance under conditions of poor usability (Moshagen et al., 2009)
- Flow experience predicts performance over and above existing skills and knowledge (Engeser & Rheinberg, 2008)
- Modelling UX to produce and represent HCI-knowledge and to guide system design - special issue of Interacting with Computers (Law & van Schaik, 2010)

User-experience models

- Existing user/product-experience models aim to account for users' experience with artefacts, but do not address cognitive task performance
- Hassenzahl (2003, 2004)
- Thüring and Mahlke (2007)
- Desmet and Hekkert (2007)
- Hartmann et al. (2008)
- Porat and Tractinsky (2012)

Rationale

- Although experience has an effect on task performance in human-computer interaction, explicit modelling of the relationship between experience and cognitive task performance is missing
- This research aims to explicitly integrate cognitive and experiential factors in the modelling of human-computer interaction

Study 1

Schaik, P. van & Ling, J. (2012a). An experimental analysis of experiential and cognitive variables in web navigation. *Human-Computer Interaction*, 27(3), 199-234.

Flow experience (1)

- Human-machine interaction process: experiential component (including flow experience) and cognitive component (including task performance)
- ‘Holistic sensation that people feel when they act with total involvement’ (Csikszentmihalyi, 1990, p. 477)
- Nine dimensions of flow distinguished and measurement instruments developed (e.g. Jackson, Eklund & Marsh, 2002; see also Pace, 2004)
- Not a matter of ‘all or nothing’ - can experience a degree of flow on each dimension

Dimensions of flow experience (Jackson & March 1996)

Dimension	Description
Balance of challenge and skill	“The person perceives a balance between the challenges of a situation and one's skills, with both operating at a personally high level.” (p. 18)
Goal clarity	“Goals in the activity are clearly defined (...), giving the person in flow a strong sense of what he or she is going to do.” (p. 19)
Feedback	“Immediate and clear feedback is received, usually from the activity itself, allowing the person to know he or she is succeeding in the set goal.” (p. 19)
Concentration	“Total concentration on the task at hand occurs when in flow” (p. 19)
Control	“A sense of exercising control is experienced, without the person actively trying to exert control.” (p. 19)
Mergence of action and awareness	“The flow activity is so deep that it becomes spontaneous or automatic.” (p. 18)
Loss of self-consciousness	“Concern for the self disappears during flow as the person becomes one with the activity.” (p. 19)
Transformation of time	“Time alters perceptibly, either slowing down or speeding up” (p. 19)
Autotelic experience	“Intrinsically rewarding experience. An activity is autotelic if it is done for its own sake, with no expectation of some future reward or benefit.” (p. 20)

Study 2

Schaik, P. van & Ling, J. (2012b). A cognitive-experiential approach to modelling web navigation. *International Journal of Human-Computer Studies*, *70*(9), 630-651.

Staged model of flow

- **Preconditions of flow: attention-enhancing component of flow**

  Challenge/skill balance, goal clarity, feedback

- **Flow proper: motivational component of flow**

  Concentration, control, action-awareness mergence, transcendence of self, transformation of time, autotelic experience

Guo and Poole (2009)

- **Effect of artefact complexity on flow mediated by preconditions of flow**
- **Limitations**
  - Complexity not experimentally controlled
  - Perceived complexity analysed rather than actual complexity
  - Antecedents, but not consequents, of flow studied

van Schaik and Ling (2012a)

- Flow is a partial mediator of the effect of experimental manipulations on task performance
- Task performance is a full mediator of the effect of flow on task outcome
- Limitations
  - Modelling of flow experience undifferentiated – no distinction between preconditions and flow proper
  - Measurement of flow not specific to HCI
  - Ad-hoc higher-order measure of flow
  - Single measure of task outcome

Aim

Clarify the relationship between experience and task outcome

- with a staged model of flow experience
- addressing limitations of previous research

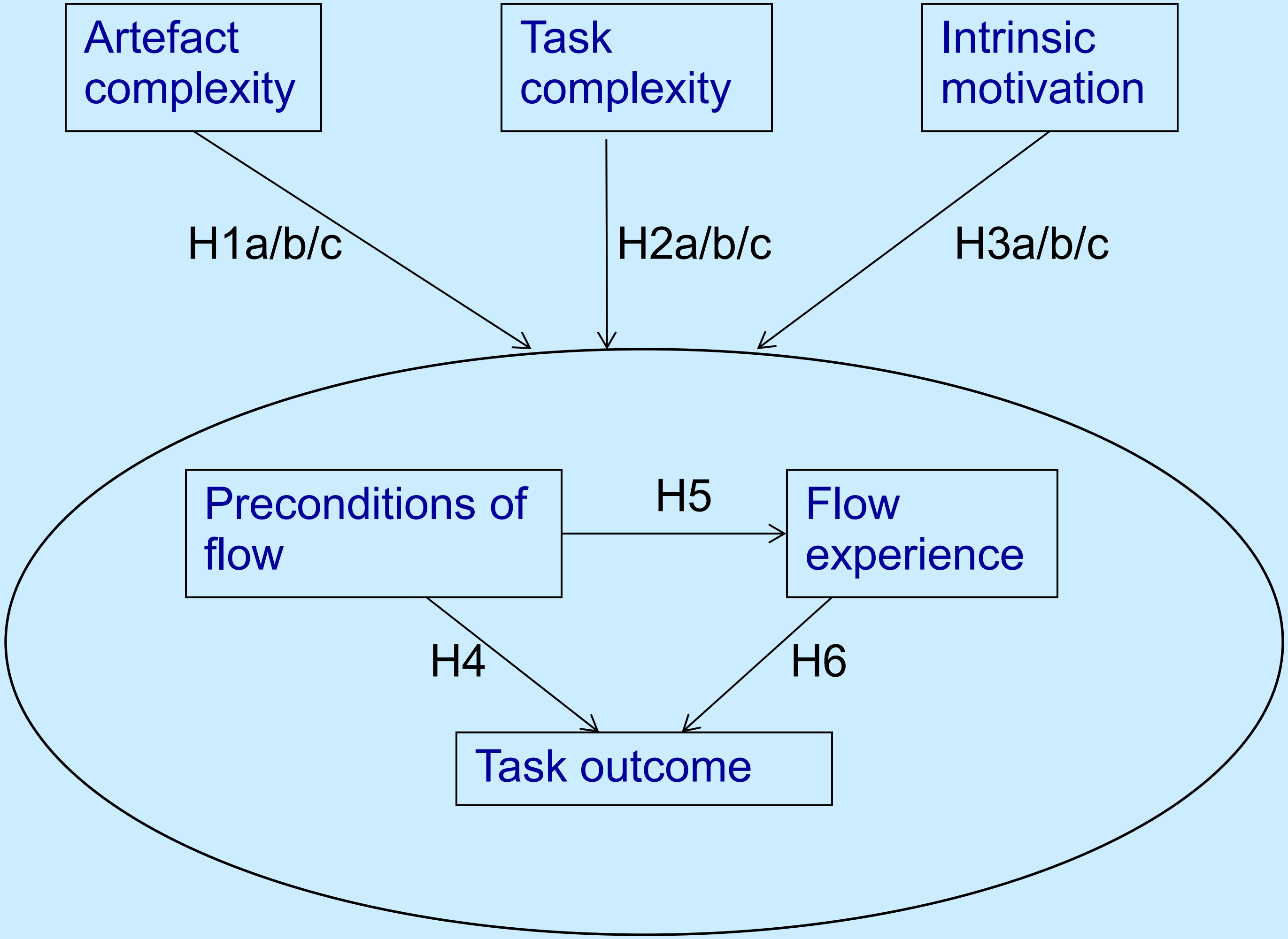
Hypotheses (continuing)

- H1a/b/c: artefact complexity has a negative effect on task outcome/preconditions/flow proper
- H2a/b/c: task complexity has a negative effect on task outcome/preconditions/flow proper
- H3a/b/c: intrinsic motivation has a positive effect on task outcome/preconditions/flow proper

Hypotheses (continued)

- H4: preconditions has a positive effect on task outcome with PAT variables held constant
- H5: preconditions has a positive effect on flow proper with PAT variables held constant
- H6: flow proper has a positive effect on task outcome with PAT variables and preconditions held constant

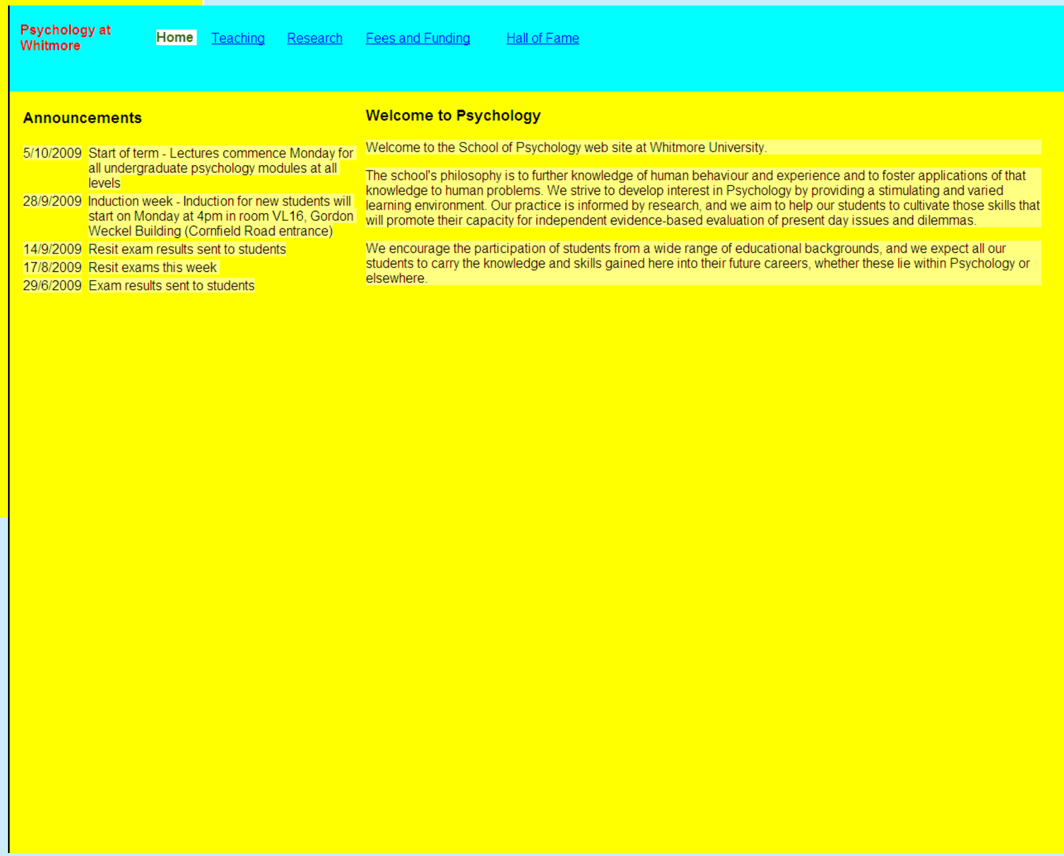
Research model

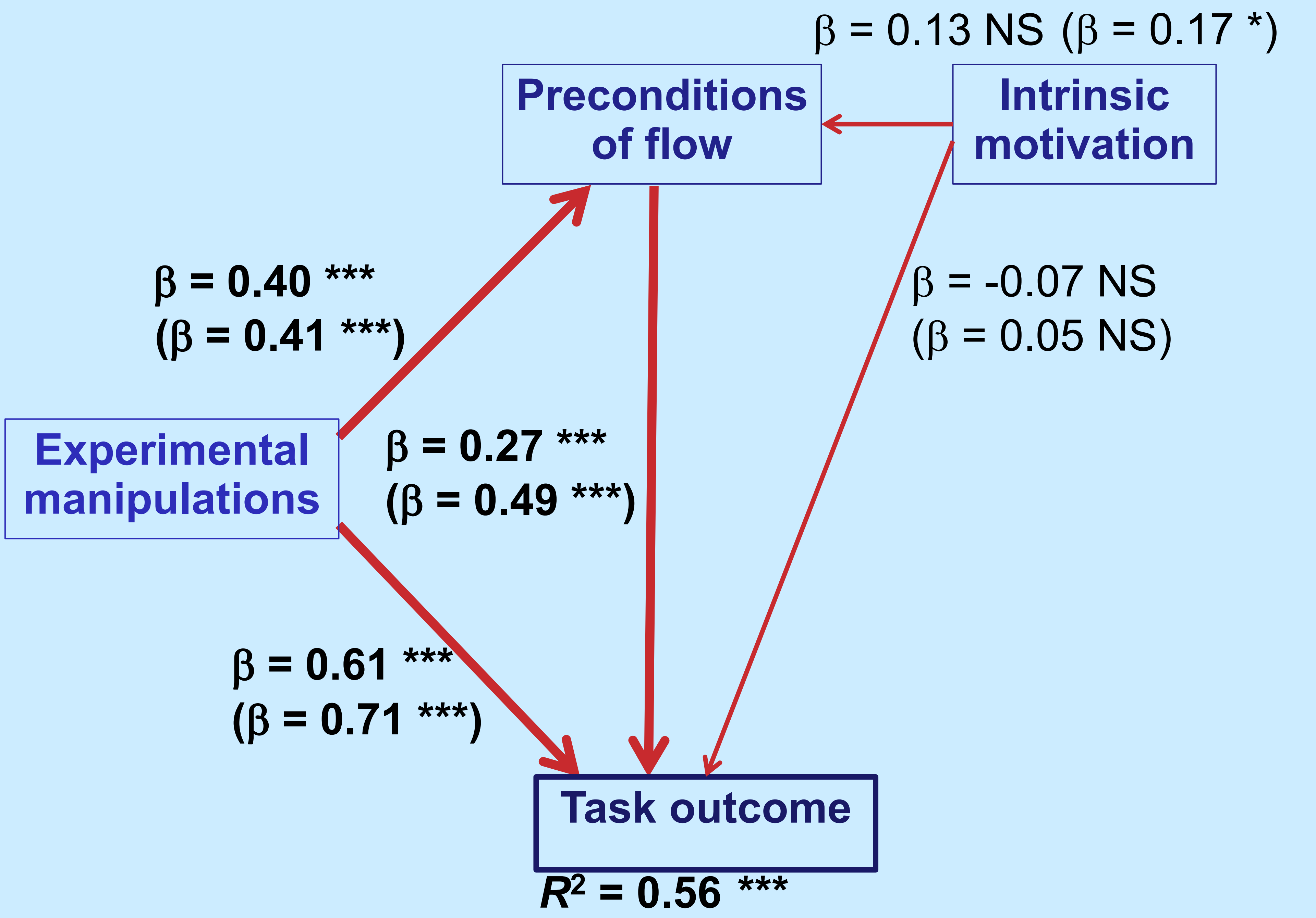


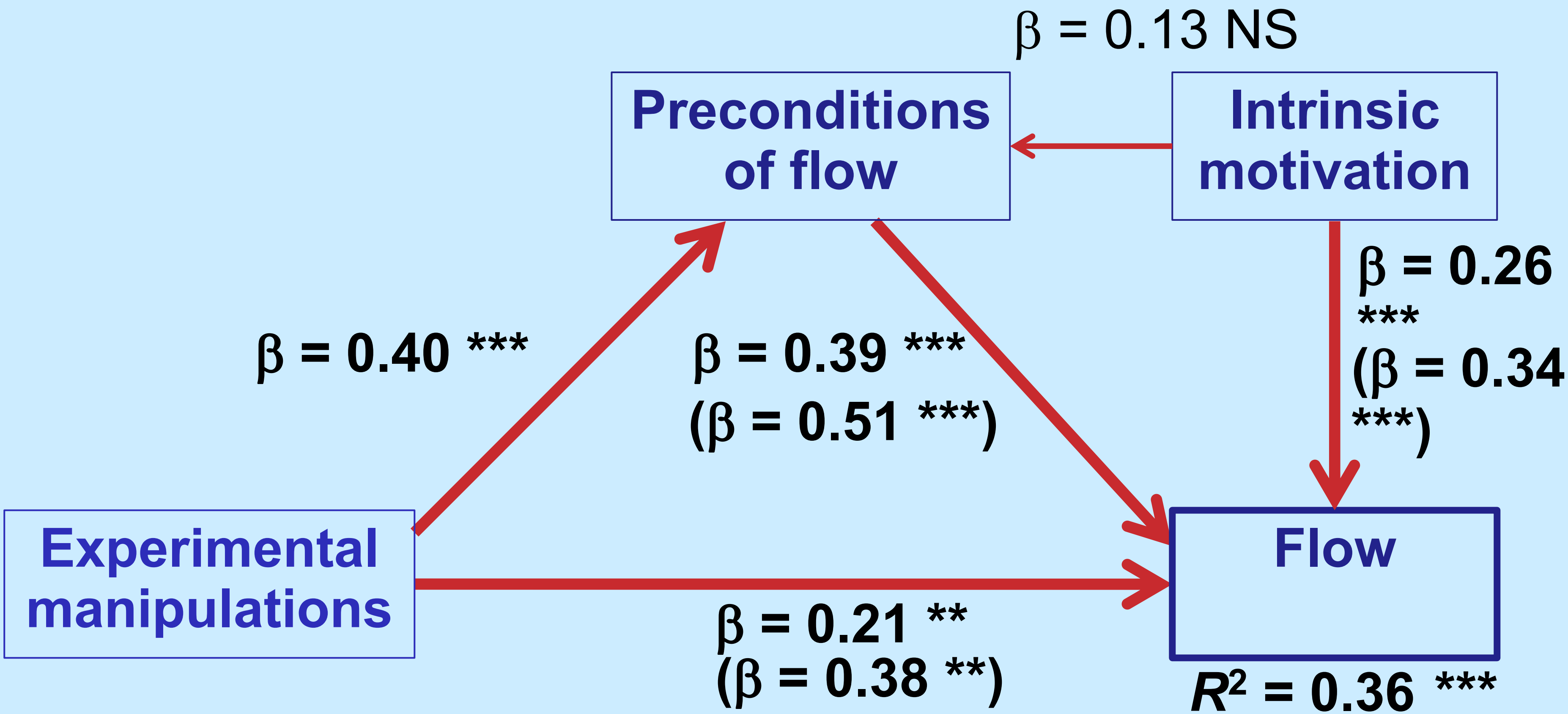
Experiment

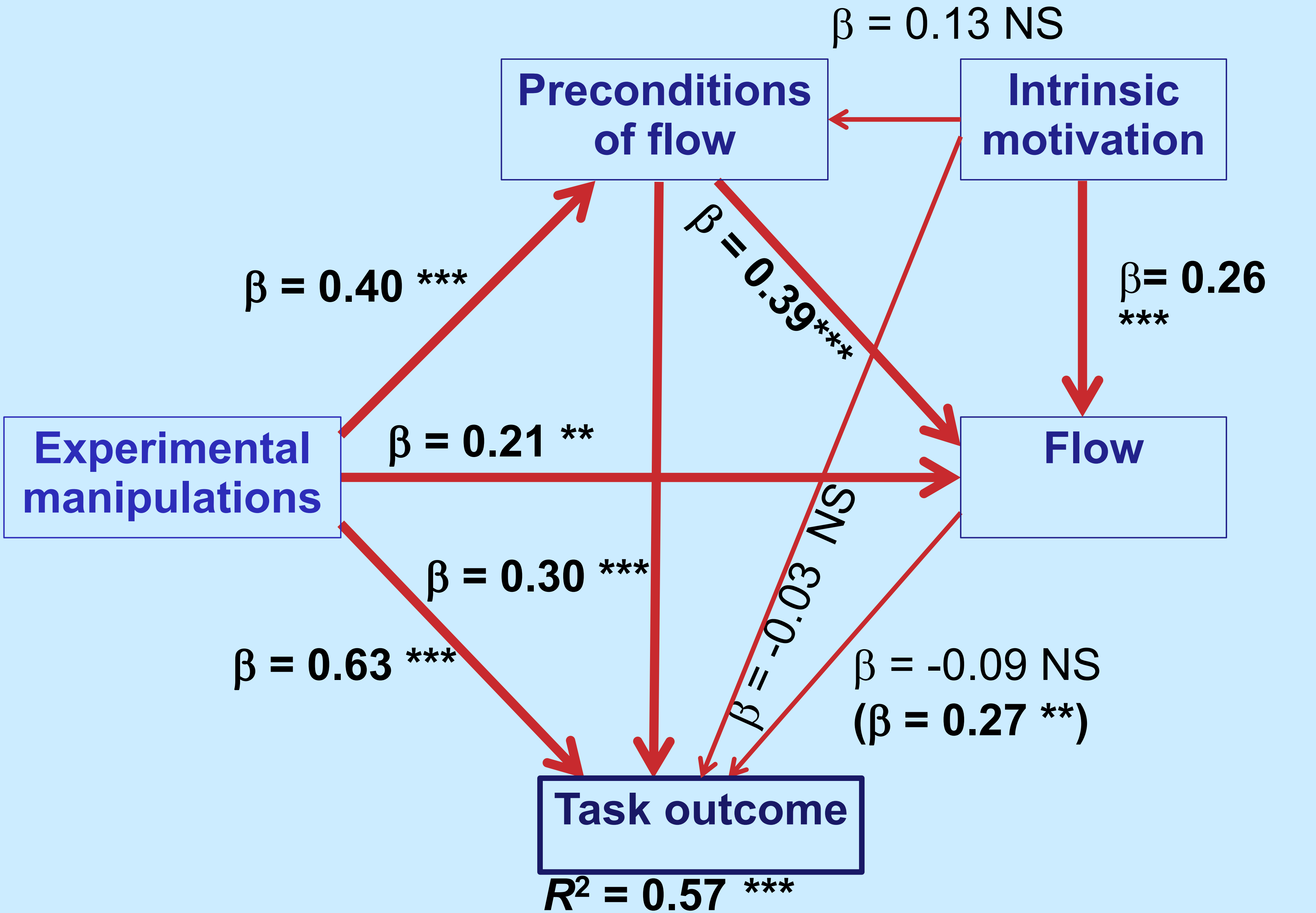
- As in van Schaik and Ling (2012a), but
- Modelling of flow experience differentiated: both preconditions and flow proper
- Measurement of flow specific to HCI (Guo & Poole, 2009)
- Theory-based higher-order measure of flow
- Multiple measures of task outcome
- N = 127

Web site versions




β = 0.13 NS (β = 0.17 *)
Preconditions of flow
Intrinsic motivation
β = 0.40 ***
(β = 0.41 ***)
β = -0.07 NS
(β = 0.05 NS)
Experimental manipulations
β = 0.27 ***
(β = 0.49 ***)
β = 0.61 ***
(β = 0.71 ***)
Task outcome
R2 = 0.56 ***


β = 0.13 NS
Preconditions of flow
Intrinsic motivation
β = 0.40 ***
β = 0.39 ***
(β = 0.51 ***)
β = 0.26 ***
(β = 0.34 ***)
Experimental manipulations
Flow
β = 0.21 **
(β = 0.38 **)
R2 = 0.36 ***



β = 0.13 NS
Preconditions of flow
Intrinsic motivation
β = 0.40 ***
β = 0.39***
β= 0.26 ***
Experimental manipulations
β = 0.21 **
Flow
β = -0.03 NS
β = 0.30 ***
β = 0.63 ***
β = -0.09 NS
(β = 0.27 **)
Task outcome
R^2 = 0.57 ***

Evaluation of hypotheses (1)

- **Effect of task complexity**

  H1a/b/c supported – evidence for cognitive task variable as a determinant of cognitive performance/preconditions/flow proper

- **Effect of artefact complexity**

  H2a/b/c/ supported – evidence for cognitive artefact variable as a determinant of cognitive performance/preconditions/flow proper

- **Effect of intrinsic motivation**

  - H3c supported – evidence for motivational personal variable as a determinant of flow proper
  - H3b partially supported
  - H3a not supported

Evaluation of hypotheses (2)

- **Effect of experimental manipulations on task outcome mediated by preconditions**

  H5 supported – evidence for preconditions as cognitive component of flow/determinant of task outcome

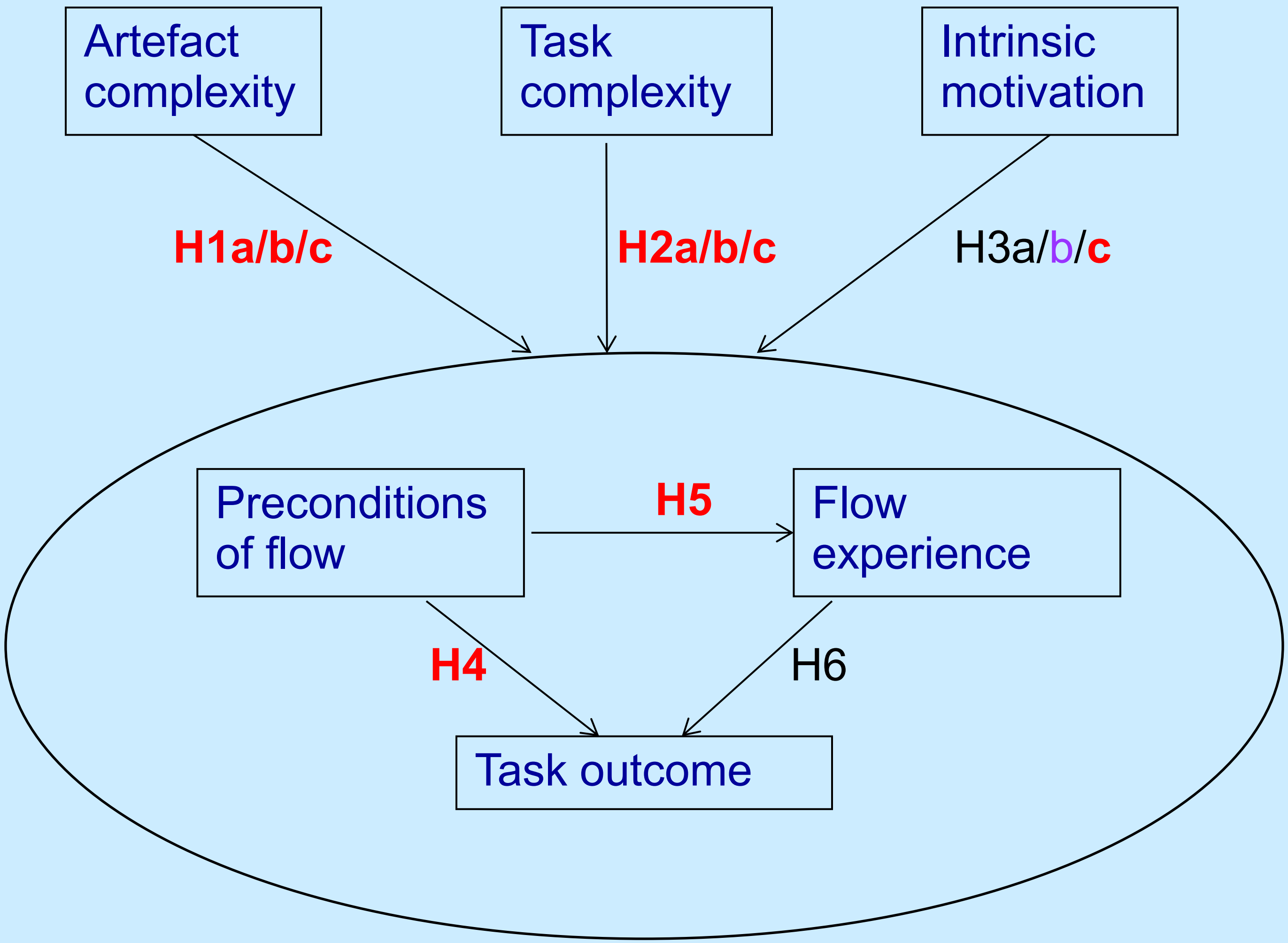
- **Effect of experimental manipulations on flow mediated by preconditions**

  H4 supported – evidence for preconditions as a determinant of flow

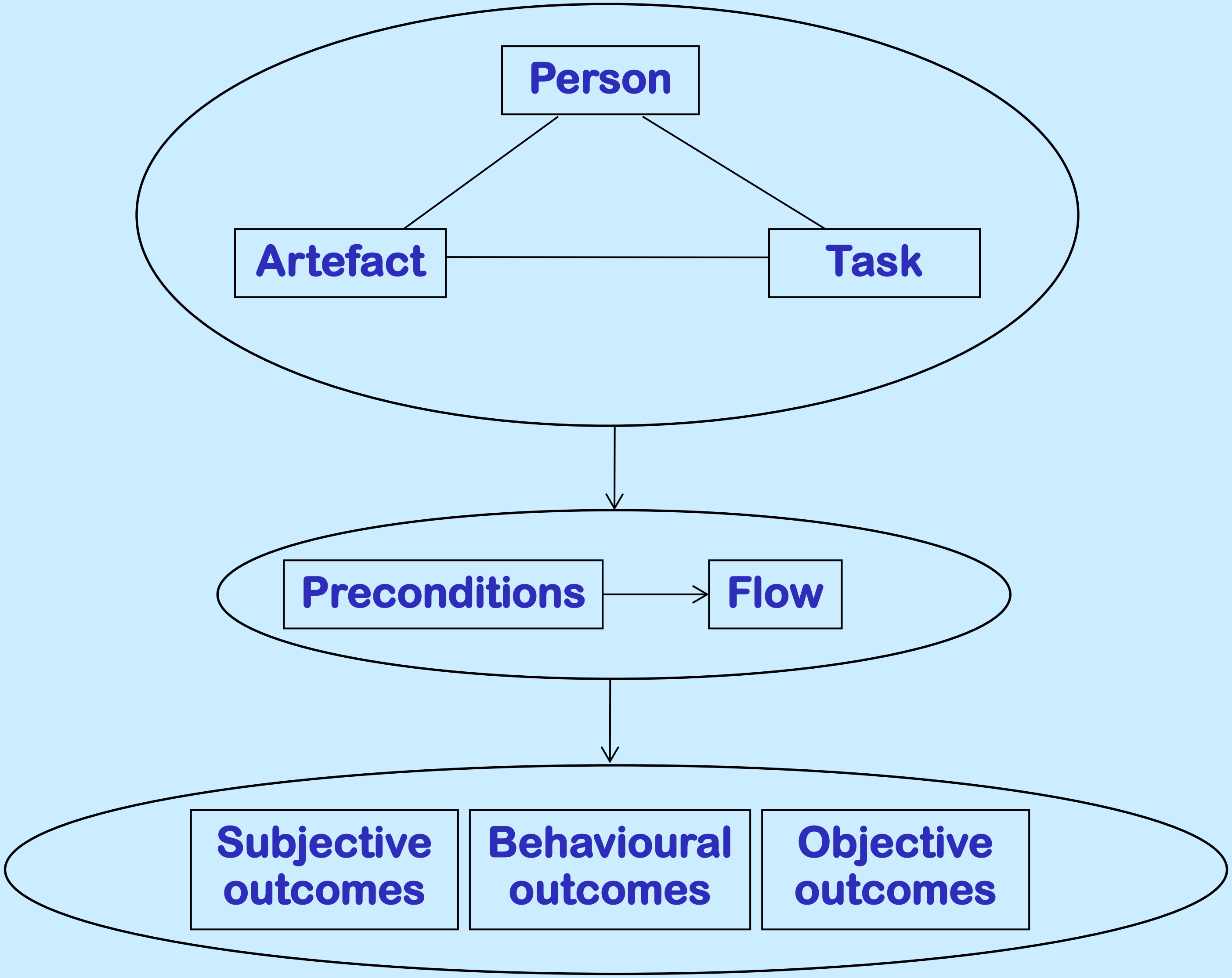
- **Effect of experimental manipulations on task outcome not mediated by flow**

  H6 not supported, but motivation expected to be a (stronger) determinant of task outcome when task importance is high (Engeser & Rheinberg, 2008)

Summary


Artefact complexity
Task complexity
Intrinsic motivation
H1a/b/c
H2a/b/c
H3a/b/c
Preconditions of flow
H5
Flow experience
H4
H6
Task outcome

Implications within research literature



Implications for HCI

By applying Norman's (1998) principles of good design usable design can promote the preconditions of flow

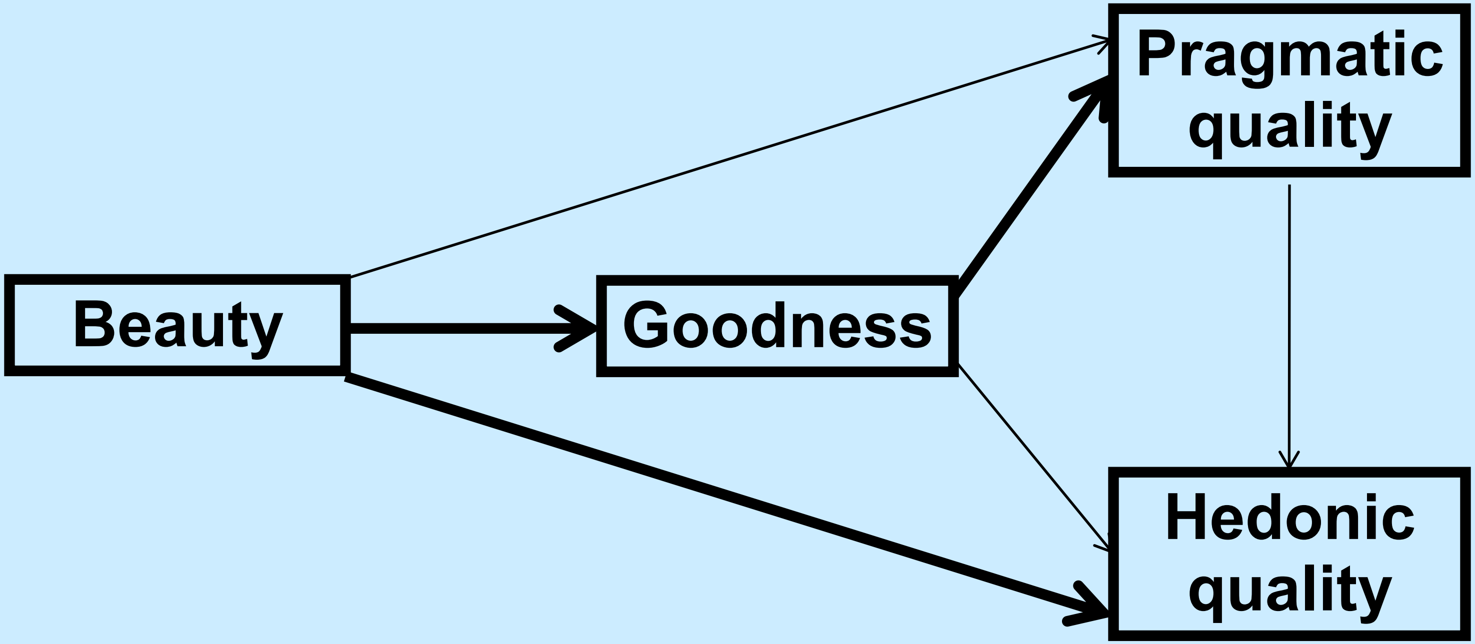
- Good conceptual mapping → challenge/skill balance
- Visibility and good mapping → goal clarity
- Feedback → feedback

Study 3

Schaik, P. van, Hassenzahl, M. & Ling, J. (2012). Modeling user-experience from an inference perspective. *ACM Transactions on Computer-Human Interaction*, *19*(2), Article 11.

Aims

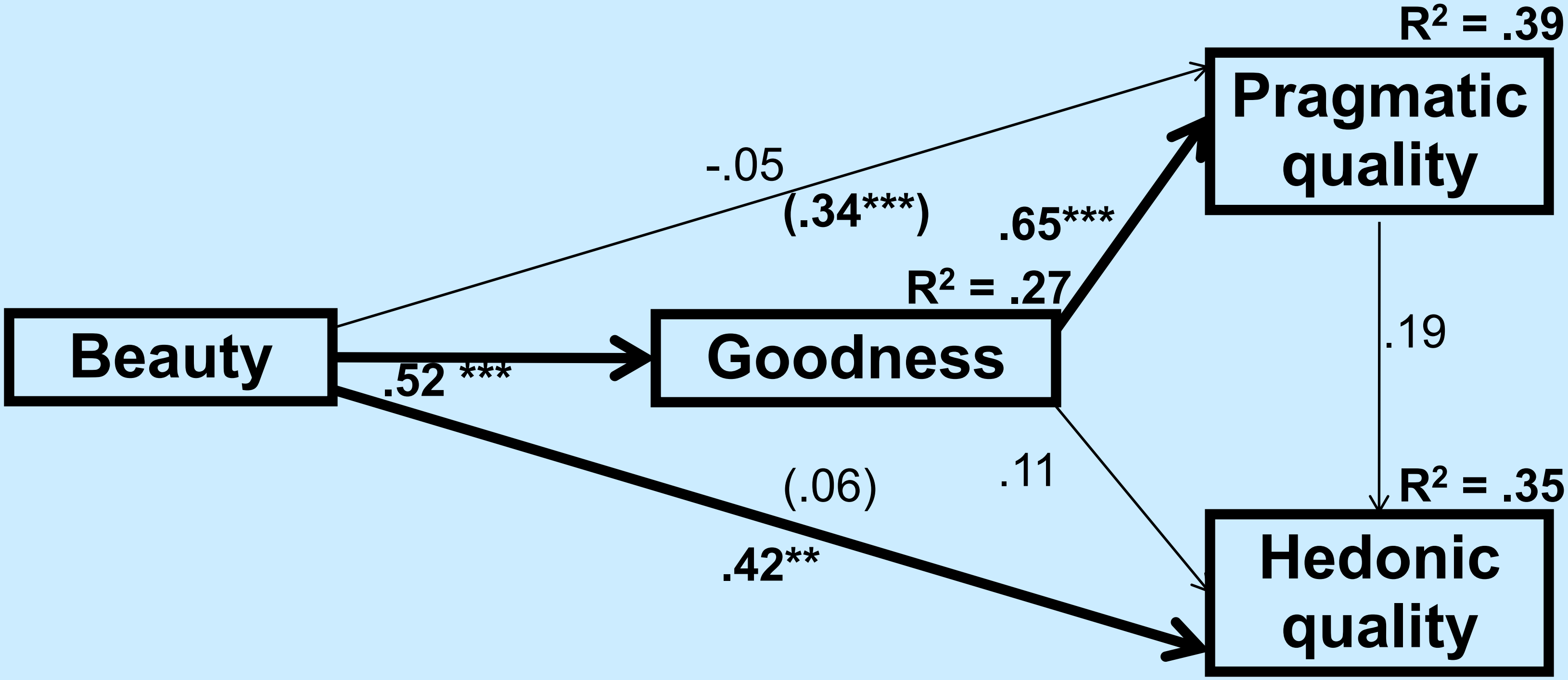
1. Replicate Hassenzahl and Monk's (2010) inference model
2. Explore potential effects of hands-on experience on the model
3. Explore how well the inference model works across different types of experience



Experiment 1: action mode

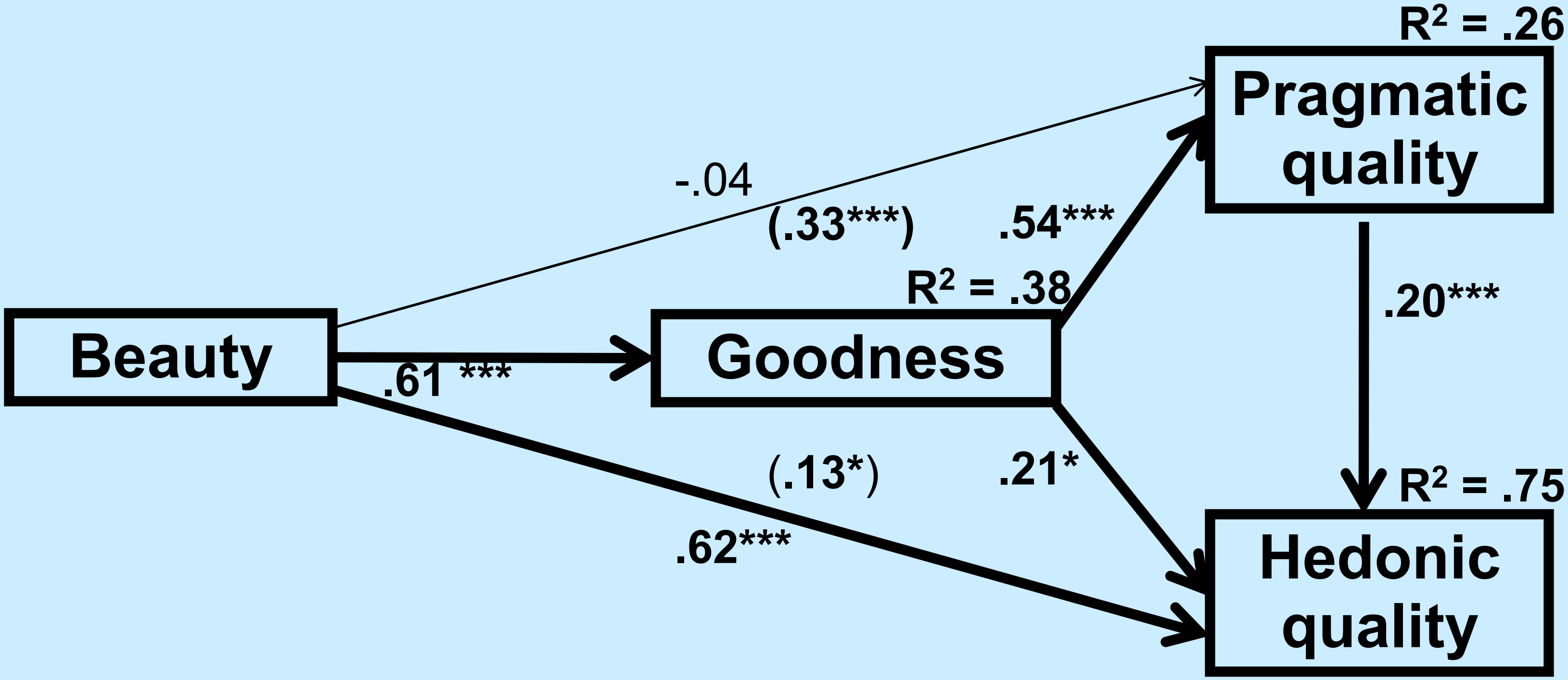
- N = 94 undergraduate students (73 females, mean age = 24, SD = 9)
- Wikipedia users
- AttrakDiff2 questionnaire
- Phase 1: viewing screenshots of Wikipedia; then UX rating
- Phase 2: exploring Wikipedia; then UX rating
- Data analysis: PLS path modelling

Before use



Beauty
Goodness
Pragmatic quality
Hedonic quality
R² = .39
R² = .27
R² = .35
-.05
(.34***)
.65***
.52 ***
.19
.11
(.06)
.42**

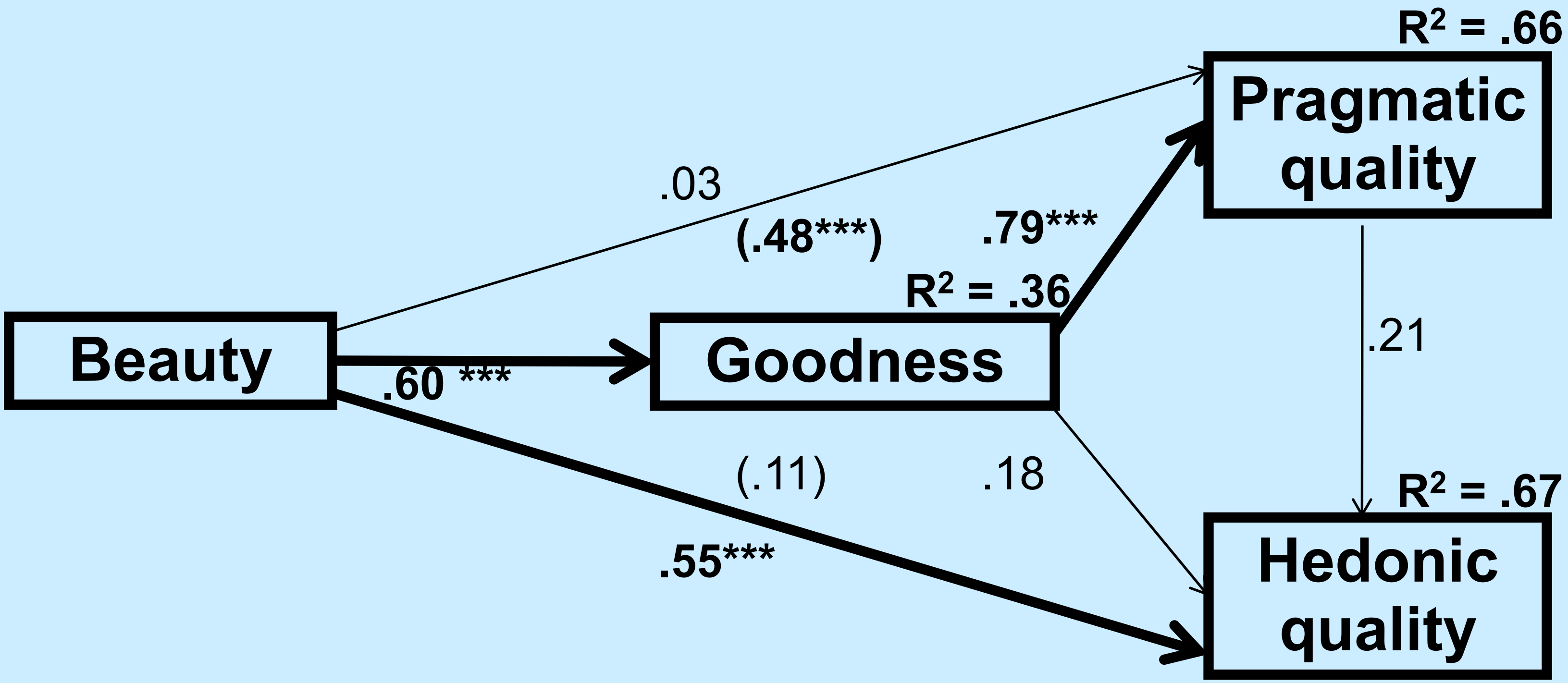
After use


R² = .26
Pragmatic quality
-.04
(.33***)
.54***
R² = .38
.20***
Beauty
Goodness
.61 ***
(.13*)
.21*
R² = .75
.62***
Hedonic quality

Experiment 2: goal mode

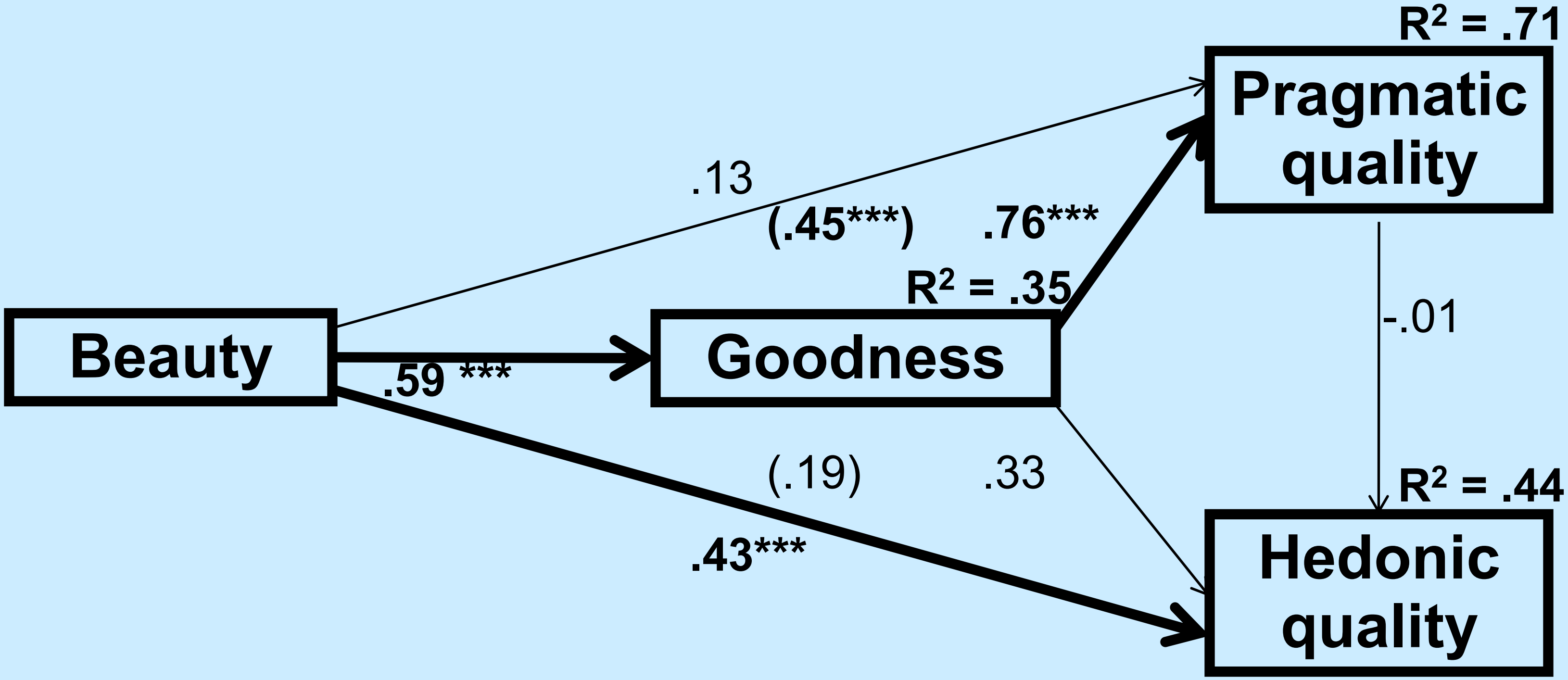
- N = 66 undergraduate students (49 females, mean age = 24, SD = 8)
- Web users
- AttrakDiff2 questionnaire
- Phase 1: viewing screenshots of Manchester City Council site; then UX rating
- Phase 2: retrieving information from site; then UX rating
- Data analysis: PLS path modelling

Before use



R² = .66
Pragmatic quality
.03
(.48***)
.79***
R² = .36
.21
Beauty
Goodness
.60 ***
(.11)
.18
R² = .67
.55***
Hedonic quality

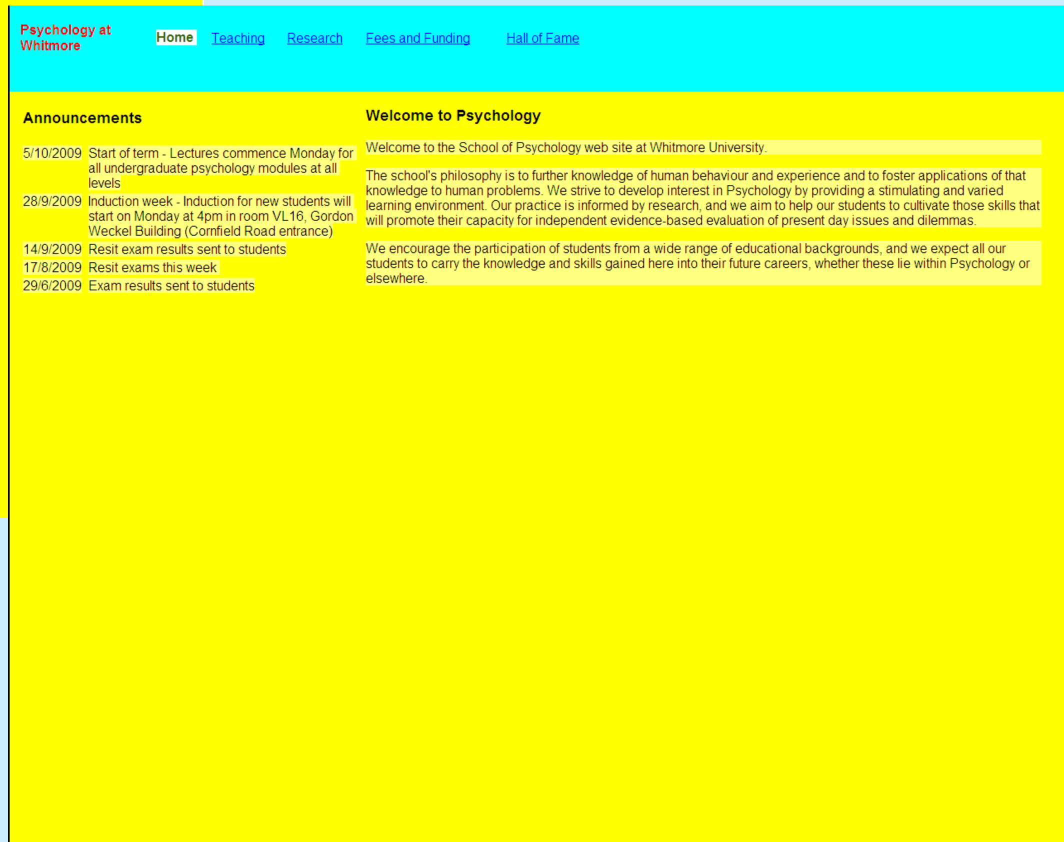
After use


R² = .71
Pragmatic quality
.13
(.45***)
.76***
R² = .35
-.01
Beauty
Goodness
.59 ***
(.19)
.33
R² = .44
.43***
Hedonic quality

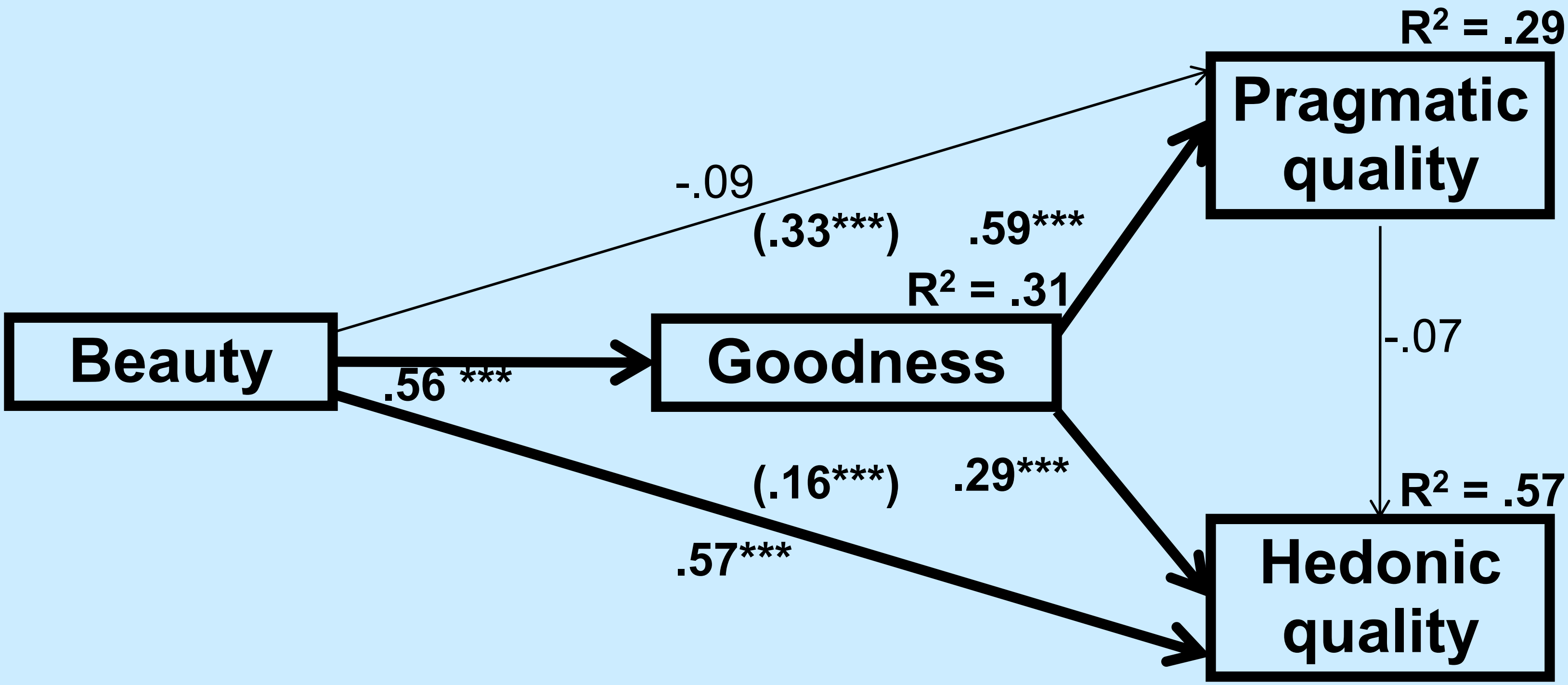
Experiment 3: goal mode with varied complexity

- 2-by-2 experimental design (task complexity [2]; artefact complexity [2])
- N = 127 undergraduate students (102 females, mean age = 23, SD = 8)
- Web users
- AttrakDiff2 questionnaire
- Phase 1: viewing screenshots of university course website; then UX rating
- Phase 2: retrieving information; UX rating
- Data analysis: PLS path modelling

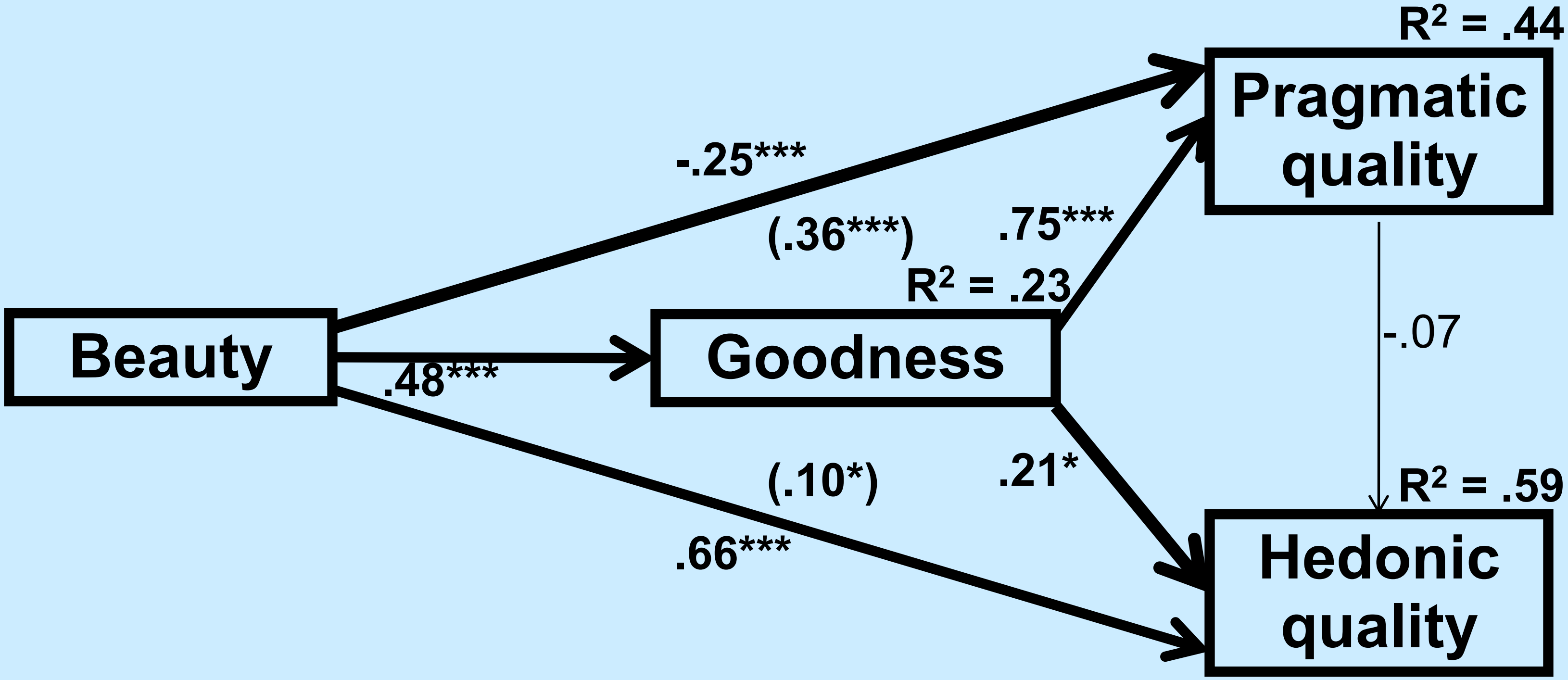
Web site versions



Before use

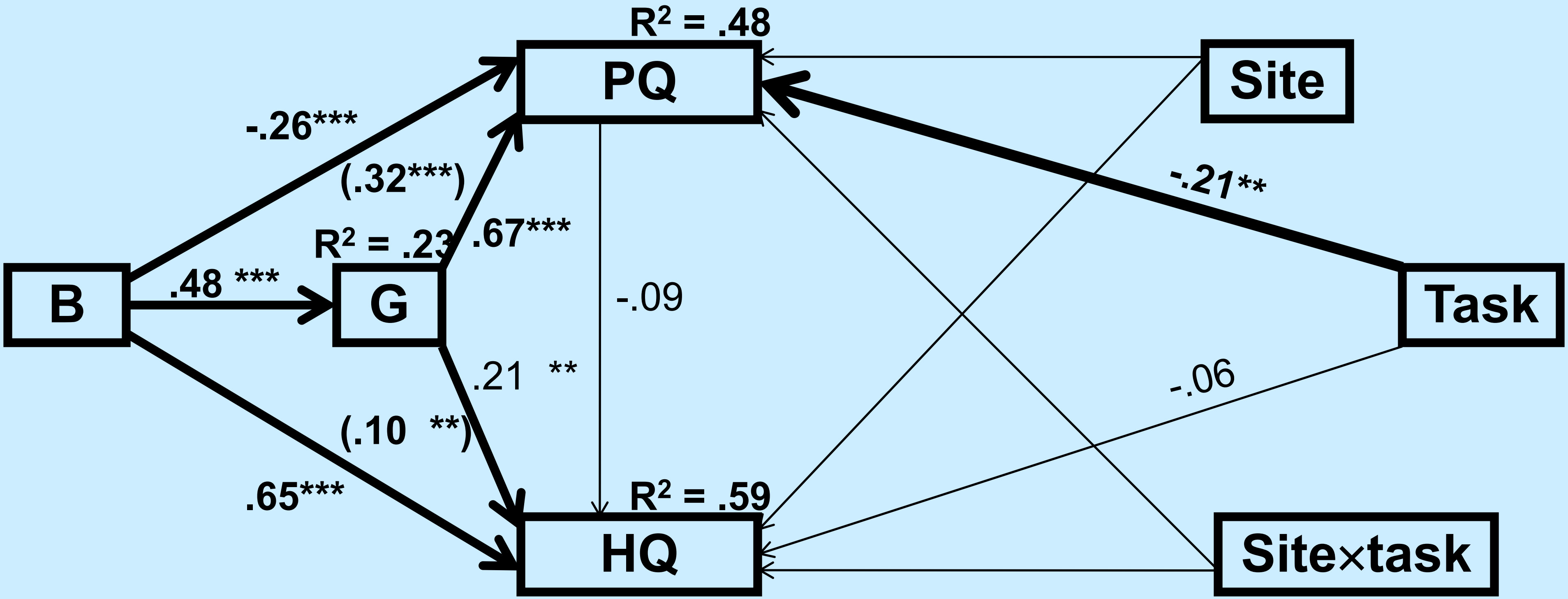

R² = .29
Pragmatic quality
-.09
(.33***)
.59***
R² = .31
Beauty
Goodness
.56 ***
-.07
(.16***)
.29***
R² = .57
.57***
Hedonic quality

After use



R² = .44
Pragmatic quality
-.25***
(.36***)
.75***
R² = .23
Beauty
Goodness
.48***
-.07
(.10*)
.21*
R² = .59
.66***
Hedonic quality

After use


R² = .48
PQ
Site
-.26***
(.32***)
-.21**
.67***
R² = .23
.48 ***
B
G
-.09
Task
.21 **
-.06
(.10 **)
.65***
R² = .59
HQ
Site×task

Discussion (Aim 1)

- Three studies supported our specific inference model
- Beauty and overall evaluation were highly correlated, confirming the longstanding inference rule of "What is beautiful is good" (Dion et al., 1972)
- Effect of beauty on hedonic quality was primarily direct (probabilistic consistency as an inference rule), but
- Effect of beauty on pragmatic quality was primarily indirect (evaluative consistency as an inference rule), in other words, mediated by goodness

Discussion (Aims 2 and 3)

- Evidence for inference rules when hands-on experience was experimentally controlled
- Evidence for the suggested inference rules

1. across two types of task (goal mode and action mode)
2. within different products (Wikipedia, council website, university course website) and
3. even when task complexity and artefact complexity were systematically varied
4. Our findings thus increase external validity

Discussion(3)

- **Beauty and pragmatic quality: compensatory inference**
- **Beauty and hedonic quality: evaluative and probabilistic consistency combined**
- **Pragmatic quality and hedonic quality:**
  - independence between pragmatic and hedonic quality may be less strong when the focus is on the action itself (‘action mode’; Hassenzahl, 2003) rather than on achieving goals
  - This is because in such a situation, the interaction itself could to some extent be a source of pleasure

Inference of UX from a wider perspective

- **Computational versus non-computational models**
- **Kruglanski et al.'s (2007) unified framework for conceptualizing and studying judgment as inference**
- **Information sources**
  - Impression from the presentation of a product
  - Hands-on experience from of subsequent interaction with the product
  - Memory of previous product experience
- **Judgement parameters of inference-based judgement**
  - Informational relevance
  - Task demands
  - Cognitive resources
  - Motivation: both non-directional (effort) and directional (bias)

Engineering approach in HCI

- **(Theoretical) model-based approach (e.g. Card, Moran and Newell)**
- **(Empirical modelling) process-based approach (e.g. Landauer)**
- **Usability engineering**
  - Process to support iterative system design
  - Aim: promote efficiency and effectiveness of task performance and satisfaction
  - Systematic process of usability-related activities, including goal-setting, operationalizing, measuring and evaluating to establish goal achievement
  - Recommendations for improving the usability of a particular artefact
  - Iterative design cycle in order to continually improve the usability of the artefact

Model-based UX-engineering

- ***Combine model-based and process-based engineering approaches***
- **Again, flexibility of UX-modelling is essential!**
- **UX-engineering in action: impact-performance analysis**
  - Representation: impact-performance matrix
  - Performance: (mean) level of predictors (e.g. specific UX or usability indicator) – mean value
  - Impact: effect on high-level outcome (UX or usability) – regression co-efficient
  - Impact-performance analysis for each high-level outcome (e.g. satisfaction)

A regression model based on real data

- Martensen and Grønholdt (2003)
- 5 libraries in Denmark
- N $\approx$ 1900
- 23 generic items
- Impact-performance:
  - Satisfaction
  - User-loyalty

Conclusion

- UX-modelling
  - develop cumulative knowledge
  - basis for UX-engineering
- Flexibility of model specification on theoretical and practical grounds is essential
- Direction of causality is crucial
- Example 1: cognitive-experiential model when task performance is important (van Schaik & Ling, 2012a, 2012b)
- Example 2: general-to-specific UX inference (van Schaik et al., 2012)