Multi-**T**asking in **MMI**

Wissenschaftliche Aussprache

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να κάνει δύο πράγματα ταυτόχρονα είναι να κάνουμε δεν

[PVBLILIVS SYRVS]

kuumuudessa

combine

“ TECHNOLOGY

is contemporary

NATURE “

[Robert Rauschenberg]


JOURNAL

1 Motivation

2 Theorie

3 Empirie

4 Diskussion

1 Motivation

2 Theorie

3 Empirie

4 Diskussion

1 MT und MMI

2 MT und Technik

3 Aktuelle Studien zu MT

4 Notwendigkeit der Arbeit

MT und MMI

- “Burgeoning popularity of in-vehicle technology“ [McCarley, 2004]

- “In-Vehicle-Information-Systems“ [Strayer & Johnston, 2001]

- “15-sec-Rule“ [Green, 1999]

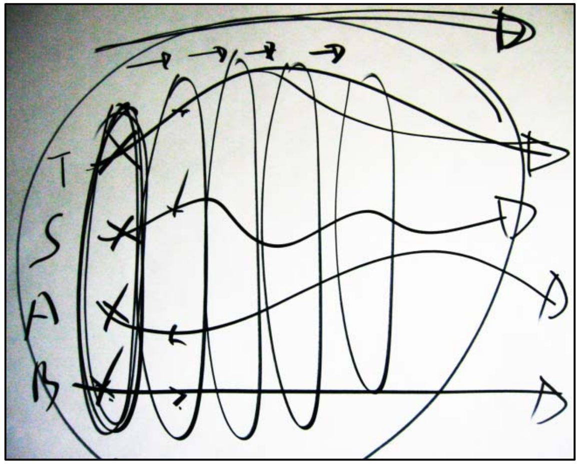
- Mobile HCI [Oulasvirta, 2006, 2005]

MT und Technik

- Techno Stress: The Human Cost of the Computer Revolution [Brod, 1984]

- Empfehlungen bei "*Multitasking Madness*" [Rosen and Weil,2005]:

1. Akkurate Zeiteinschätzung für Aufgaben
2. Externalisierung (Reduzierung von kognitiver Belastung)
3. Fokusierung auf eine einzelne Aufgabe
4. Down-Time (Refreshing)



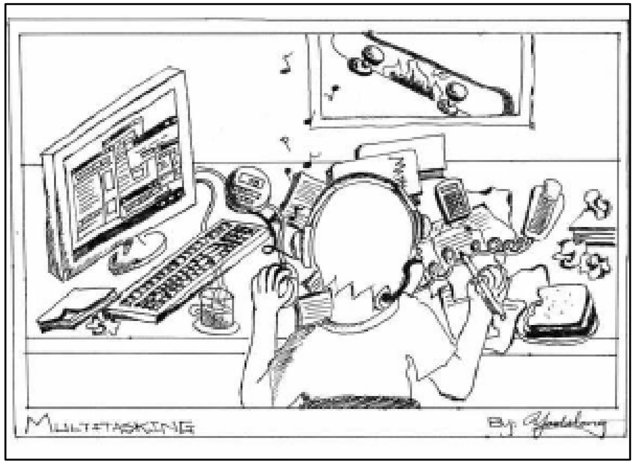
Aktuelle Studien zu MT

- Salvucci [2005]: driving (1st task) + cell phone dialing (2nd task)

1. Models of discrete successive tasks
2. Models of discrete concurrent tasks
3. Models of elementary continuous tasks
4. Models of compound continuous tasks

MT as "***ability to integrate, interleave, and perform multiple tasks and/or component subtasks of a larger complex task***"

(discrete: duration < 10 s, vs. continuous: duration > 10 s)



Notwendigkeit der Arbeit

- Kritik an aktuellen Studien zu MT:

1. Fehlender **Anwendungsaspekt** (kein Bezug zum realen Alltag)
2. Keine **Aufgabenwiederholung**, keine **systematische** Analyse

- Folge: Anforderungen an die **Zweitaufgabe**
    - vollständig kontrollierbar
    - kontext-unabhängig
    - unterbrechbar
    - beobachtbar

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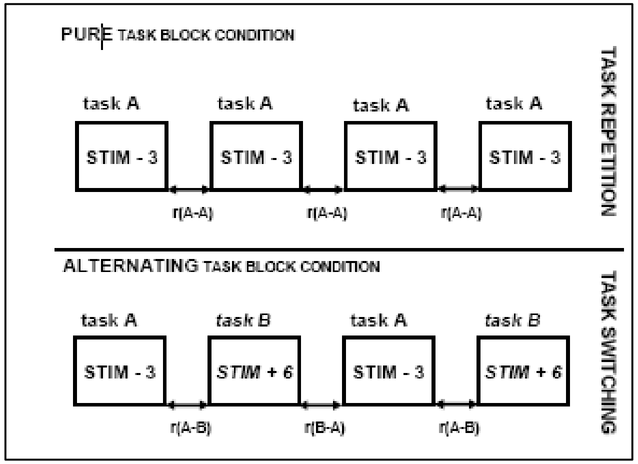
1 Historischer Überblick

2 MT vs. Task-Interruption

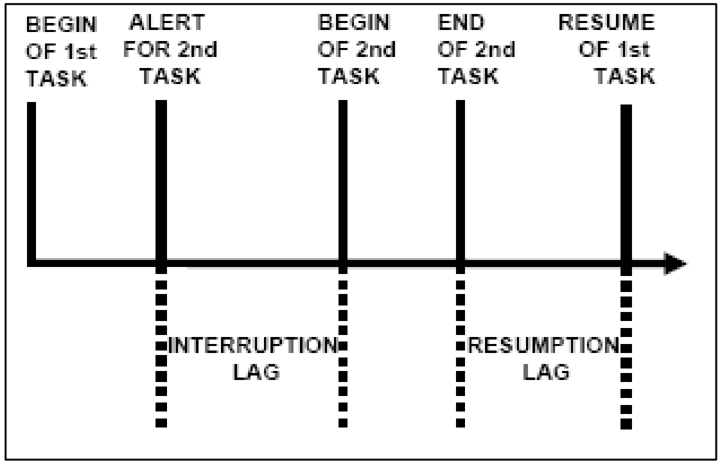
3 Single vs. Multiples Resources

4 Kritische Betrachtung



Historischer Überblick

- *Jersild [1927]:* Erste empirische Ansätze zu Aufgabenwechsel
- *Telford [1931]:* Psychological Refractory Period (PRP)
- *Bis 1980:* Verschiedene Variationen dieser Aufgaben
- *Pashler [2000]:* Central Bottleneck (Keine Parallelität möglich)
- *Schumacher[2001]:* Virtually-Perfect Time-Sharing (PsychScience)
- *Salvucci [2005]:* Compound Continuous Tasks



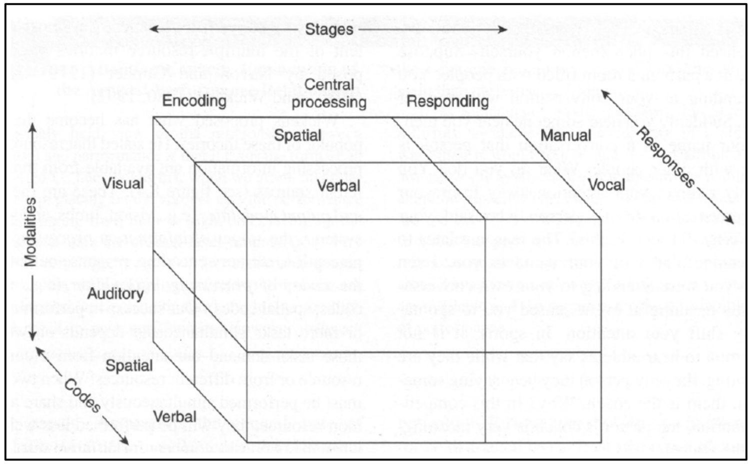
MT vs. Task-Interruption

- McFarlane [1998]: Taxonomie zu Task-Interruption

- Charakteristika nach Trafton [2002] mit Fokus auf:

  - Verfügbarkeit der Hauptaufgabe während der Unterbrechung
  - Dauer und Art der Unterbrechung einer (Haupt-) Aufgabe

➔ Das Hauptinteresse meiner Arbeit besteht darin, zu „verstehen", **wie Menschen im Alltag MT Situationen** „meistern", nicht jedoch in einer systematische Analyse unterschiedlicher Unterbrechungsvarianten/-variationen



Single vs. Multiple Resources

- Wickens [2004]:
  1. processing stages (*perception, cognition, responding*)
  2. perception modalities (*visual vs. auditory*)
  3. visual processing (*focal vs. ambient*)
  4. processing codes (*spatial vs. verbal*)

➔ **Aufmerksamkeitsteilung** ist stabiler (geringere Leistungs-einbussen) unter sog. „*cross-modal time-sharing*" im Vergleich zu „*intra-modal time-sharing*" = **ermöglicht MT**

➔ Unterschiedliche Ressourcen für einzelne Verarbeitungsstufen

Domain	Architecture(s)	Reference
Discrete Successive Tasks		
Alternating choice	ACT–R	Altmann & Gray, 2000
Alternating choice	EPIC	Kieras et al., 2000
Alternating choice	ACT–R	Sohn & Anderson, 2001
Discrete Concurrent Tasks		
Dual choice	EPIC	Meyer & Kieras, 1997
Dual choice	ACT–R	Byrne & Anderson, 2001
Dual choice	ACT–R	Anderson, Taatgen, & Byrne, in press
Elementary Continuous Tasks		
Tracking and choice	EPIC	Kieras & Meyer, 1997
Tracking and choice	EPIC–SOAR	Chong, 1998
Tracking and choice	SOAR, EPIC	Lallement & John, 1998
Compound Continuous Tasks		
Air traffic control (KA-ATC)	ACT–R	Taatgen & Lee, 2003
Air traffic control (AMBR)	ACT–R, D-COG, EPIC–SOAR, iGen	Gluck & Pew, in press

Kritische Betrachtung

- Die meisten Studien betrachten lediglich ***diskrete*** Aufgaben.

- Bei Studien mit kontinuierlichen Aufgaben ***fehlen***

1. Alltagsbezogenes Experimentaldesign [Studie I]
2. Aufgabenwiederholung & Übungsaspekte [Studie II]
3. Systematische Kontrolle der Zweitaufgabe [Studie III]
4. Situationsfaktoren (z.B. Zeitdruck) [Studie IIII]

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1 I: Identifizierung von MT-Heuristiken

2 II: Auswirkungen von Übung auf MT

3 III: Aufgabenkonfiguration und MT

4 IIII: Zeitdruck und MT

I: Identifizierung von MT-Heuristiken
Wie verhalten sich Personen in alltagsnahen Situationen unter MT?

II: Auswirkungen von Übung auf MT
Welche Auswirkungen haben Übung und Aufgabenwiederholung auf die Leistung unter MT?

III: Aufgabenkonfiguration und MT
Wie wirkt sich die Aufgabenkonfiguration auf das Verhalten unter MT aus?

IIII: Zeitdruck und MT
Welche Rolle spielt Zeitdruck beim MT?

IIII: Zeitdruck und MT

Welche Rolle spielt Zeitdruck beim MT?

IIII: Zeitdruck und MT **Ausgangspunkt**

Welchen Einfluss hat Zeitdruck auf die Leistung beim MT?

UV1: Zeitdruck (bezogen auf beide Aufgaben), *within-subject*
geringer Zeitdruck: Priorisierung von sicherem Fahren
hoher Zeitdruck: Leistungsorientierte Instruktion
UV2: Aufgaben-Komplexität (Zweitaufgabe), *within-subject*

AV1: Leistung in der Hauptaufgabe (Spurabweichung)
AV2: Leistung in der Nebenaufgabe (Anzahl bearbeiteter Muster)
sowie *Verbal Reports, Demographie*

Design: 2x2, N = 36 (40-4, techn. Probleme)

Hyp.: Zeitdruckt übt sich negativ auf beide AVi aus
Aufgaben-Komplexität hat einen negativen Einfluss
Ordinale Interaktion (grössere Distanz unter hohem Zeitdruck)

Hauptaufgabe

kontinuierlich

unterbrechbar

leicht erlernbar

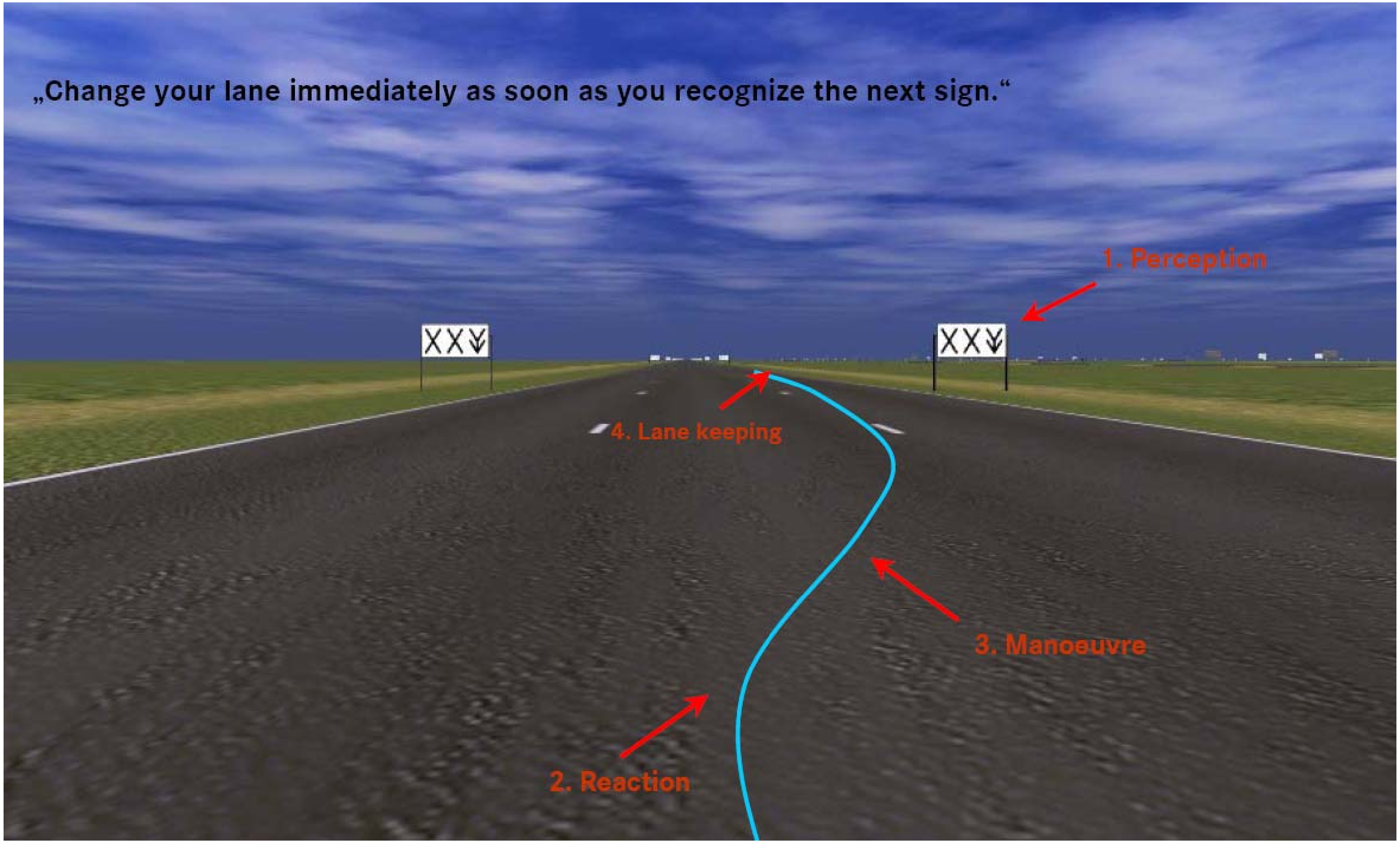
vergleichbar (zwischen VPN)

visuelle Aufmerksamkeit

kognitive Verarbeitung

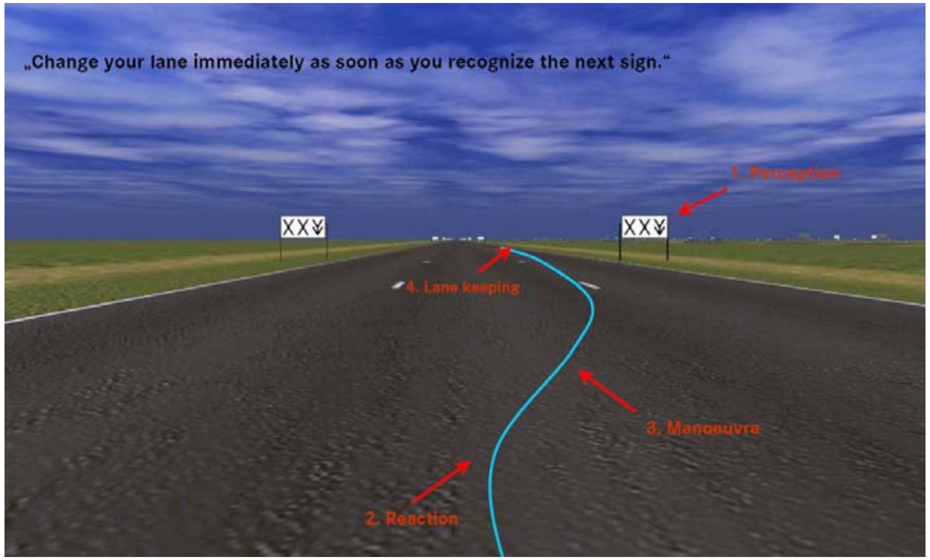
Leistung systematisch analysierbar

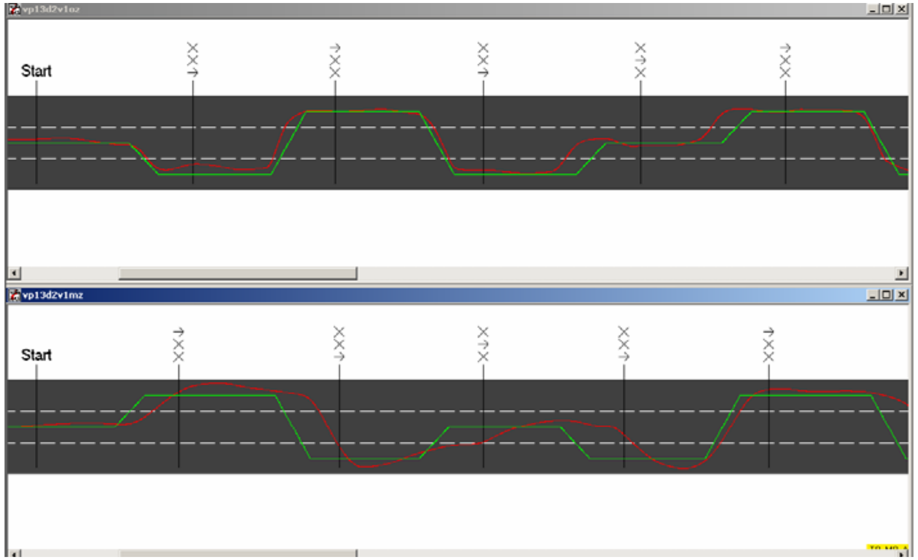
im Mensch-Maschine - Kontext


„Change your lane immediately as soon as you recognize the next sign."
1. Perception
4. Lane keeping
3. Manoeuvre
2. Reaction

IIII: Zeitdruck und MT

Erstaufgabe





- *Lane Change Task* (LCT, "ISO/DIS 26022: Simulated Lane Change Test To Asses Driver Distraction“) [Mattes, 2003]

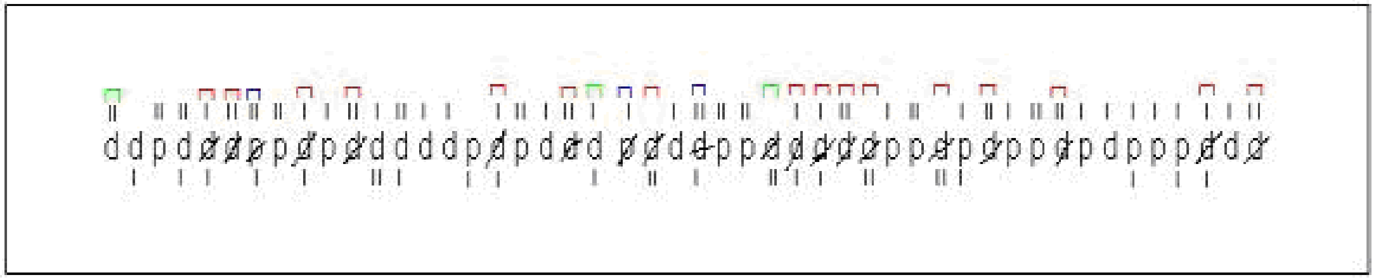
  (1) Perception (road sign) + interpretation
  (2) Action (start maneuver) + memorizing sign (rehearsal)
  (3) Action (perform lane change)
  (4) Action (keep lane) + check of next sign

Performance Measure: Lane Derivation (Software: LCTA, Bild rechts)

IIII: Zeitdruck und MT **Zweitaufgabe**

Gesucht wurde ein Aufmerksamkeitstest, der

- visuelle Aufmerksamkeit erfordert (*visual attention*)
- leicht erlernbar ist (*accessibility*)
- kultur-unabhängig und sprachunabhängig ist
- unterbrechbar & wiederaufnehmbar ist (*interruption & resumption*)

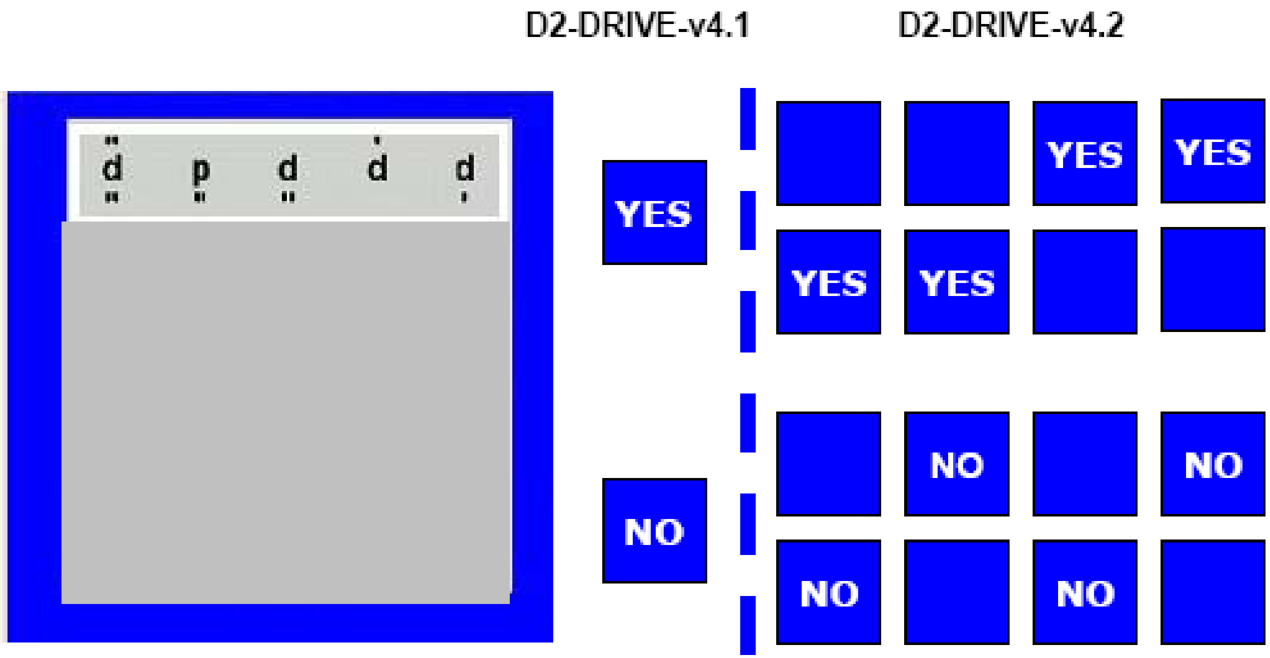


D2-Test [Brickenkamp, 1992] misst residuale Ressourcen, erfordert Kognition (*reading, deciding*) und Handlung (*manual response*)

I IIII: Zeitdruck und MT

Zweitaufgabe

Für alle 4 durchgeführten Studien wurde der D2-Test angepasst ("D2-Drive")



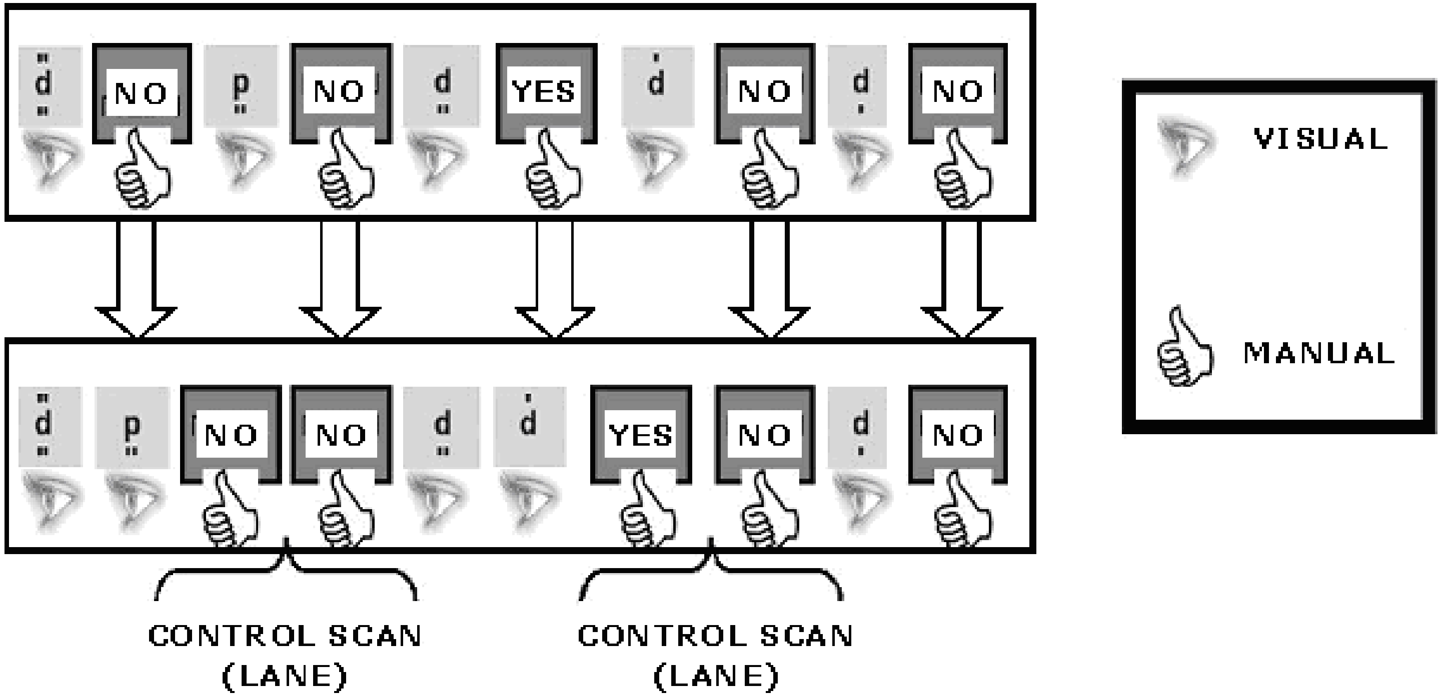
In Studie IIII wurden 2 Varianten (ease of use - level) eingesetzt:
- klare Unterscheidung bzgl. erforderlicher Zeit (reaction time)
- klare Unterscheidung bzgl. notwendiger visueller Aufmerksamkeit

d2-drive-v4.1: Zeile und Antwort-Knöpfe bleiben unverändert
d2-drive-v4.2: Zeile und Antwort-Knöpfe ändern sich

I IIII: Zeitdruck und MT ***Ablauf (11-13 syst. variiert)***

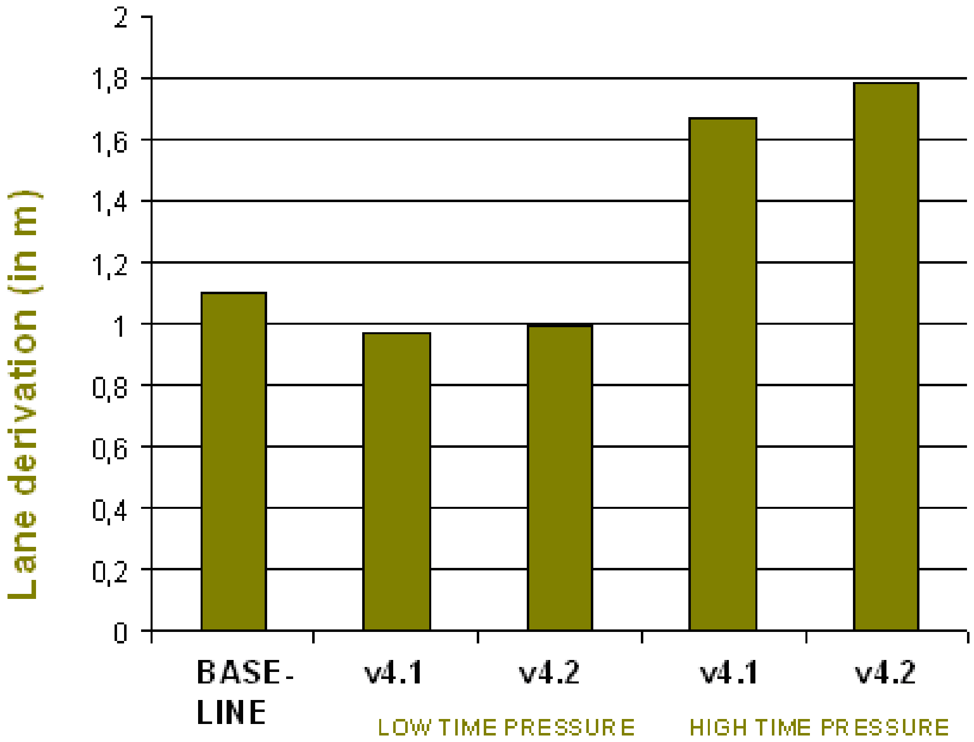
01. Begrüssung
02. Technische Vorbereitung
03. Erholungsphase für Versuchsteilnehmer [02min]
04. Baseline (Physiology)
05. Kalibrierung (Blickdaten)
06. Training Hauptaufgabe (LCT) [1 Strecke]
07. Training Nebennaufgabe (D2-Drive-v4.1) [01min]
08. Single task (D2-Drive-v4.1, Pretest) [01min]
09. Training Nebenaufgabe (D2-Drive-v4.2) [01min]
10. Single task (D2-Drive-v4.2, Pretest) [01min]
11. *Dual task session (driving and D2-Drive-v4.1): low time pressure*
12. *Dual task session (driving and D2-Drive-v4.2): low time pressure*
13. *Dual task session (driving and D2-Drive-v4.1): high time pr.*
14. *Dual task session (driving and D2-Drive-v4.2): high time pr.*
15. Single task (D2-Drive-v4.1, Posttest) [01min]
16. Single task (D2-Drive-v4.2, Posttest) [01min]
17. Demographische Daten

IIII: Zeitdruck und MT ***Merge-Heuristic***



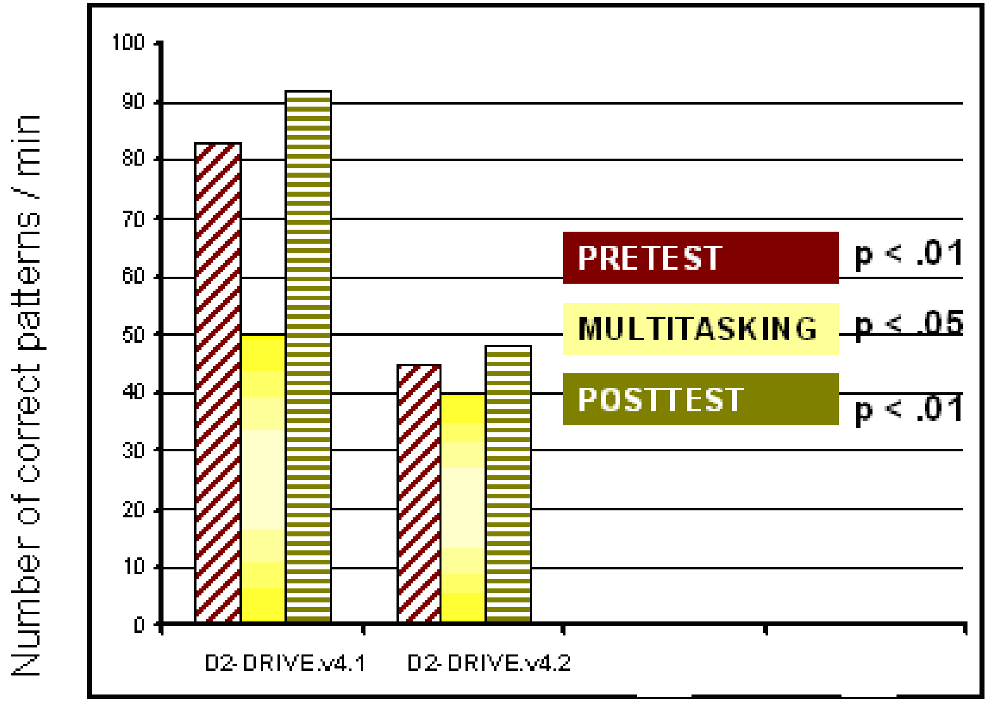
Das bereits in den Studien I-III aufgezeigte Verhalten (Anwenden einer sog. **Heuristik**) konnte auch hier gefunden werden und hilft bei der Erklärung der im Folgenden aufgeführten Ergebnisse.

IIII: Zeitdruck und MT ***Resultate: Fahrverhalten***



Aufgabenschwierigkeit (Zweitaufgabe) hat keinen Einfluss auf das **Fahrverhalten**, allerdings wirkt sich **Zeitdruck** deutlich ($p < 0.01$) auf die Spurabweichung aus. Die (*nicht sign.*) bessere Fahrleistung unter geringem Zeitdruck bzgl. zur Baseline ist ein Lerneffekt.

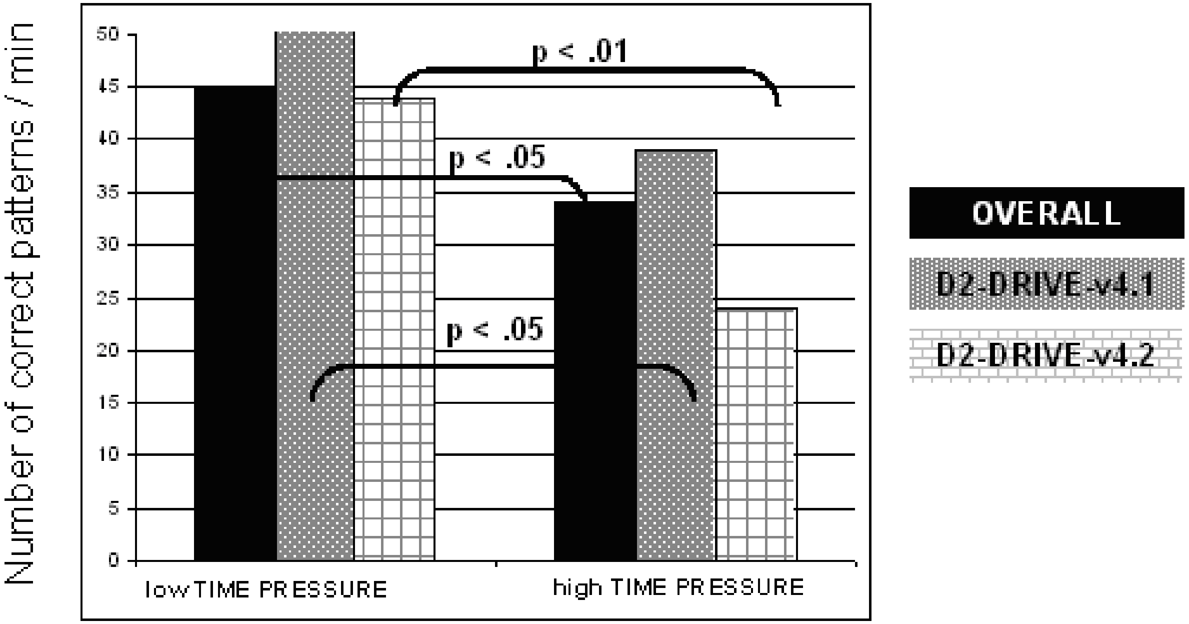
IIII: Zeitdruck und MT *Resultate: D2-Drive*



In allen Bedingungen (Pretest, MT, Posttest) ergibt sich ein Haupteffekt für die **Aufgabenschwierigkeit**.

Unter MT zeigt sich für die “leichtere” D2-Version im Vergleich zu Pretest und Posttest eine signifikante Verschlechterung.

IIII: Zeitdruck und MT ***Resultate: D2-Drive***



Zeitdruck wirkt sich sign. negativ auf die **Leistung im D2-Drive** aus ($p < 0.05$). Hoher Zeitdruck hat einen stärkeren Einfluss auf die schwierigere Variante der Zweitaufgabe. Das erklärt, warum bereits in Pre-bzw. Post-Test die Leistung in D2-Drive-4.2 so gering ist.

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1 Fragestellung und Befunde

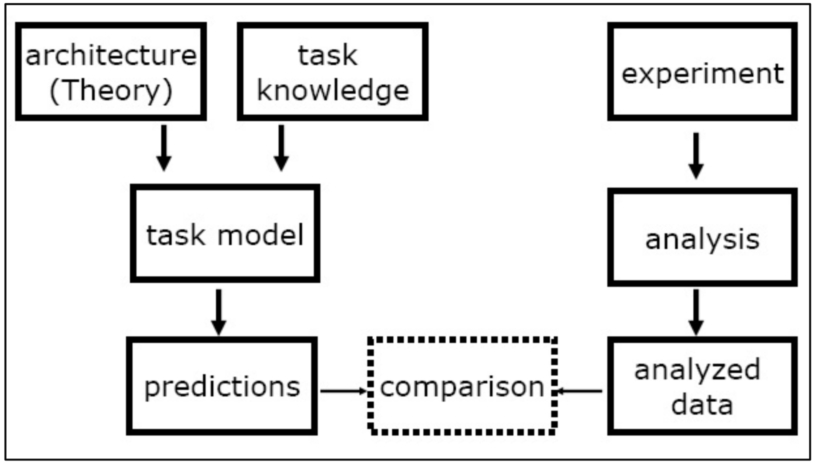
2 Kognitive Modellierung

3 Design-Empfehlungen

4 Kritik und Ausblick

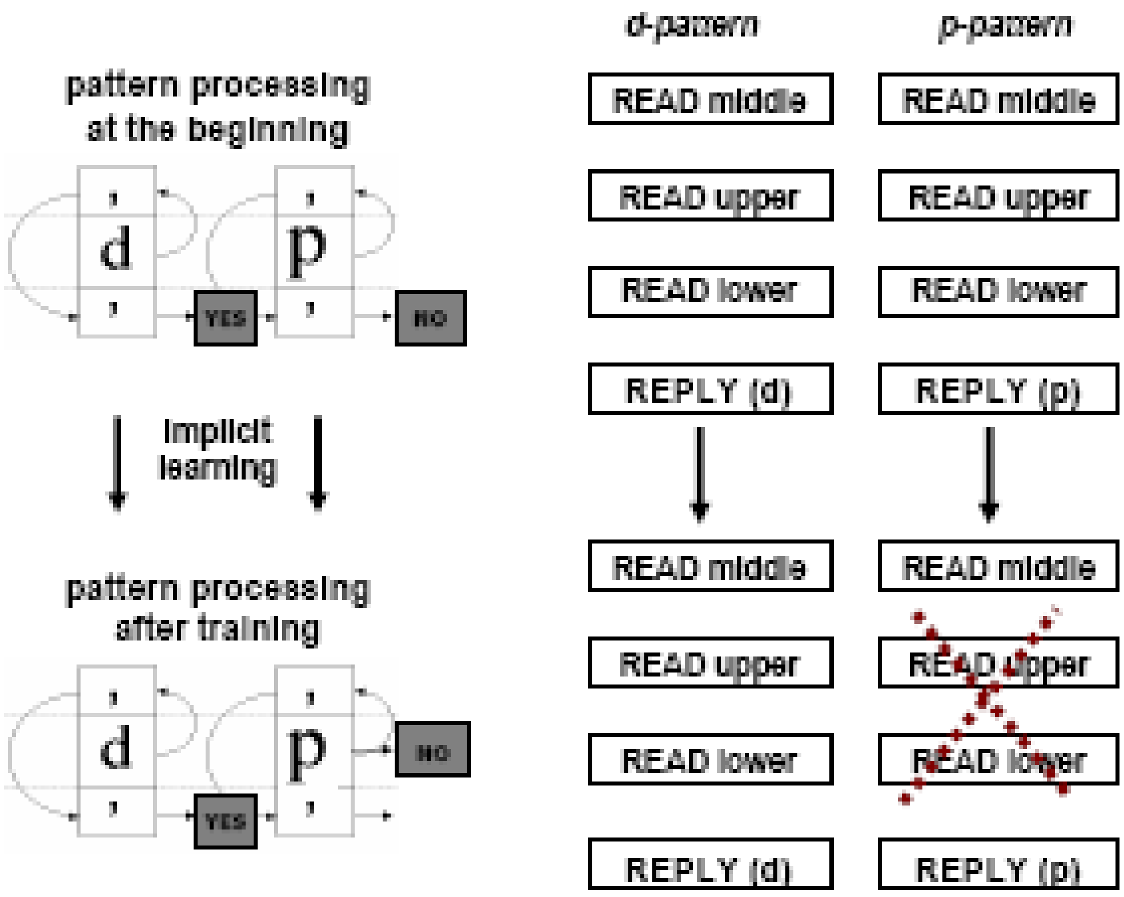
Fragestellung und Befunde

1?. Verhalten unter MT	1!. Anwendung von Heuristiken
2?. Auswirkungen von Übung	2!. allg. Leistungssteigerung
3?. Rolle der Aufgabenkonfiguration	3!. bestimmt MT-Strategie
4?. Einfluss von Zeitdruck	4!. auf Haupt- & Nebenaufgabe



Kognitive Modellierung

- Zur Überprüfung der getroffenen Annahmen wurde parallel zur empirischen Testung ein ACT-R - Model [Anderson, 2007] erstellt
- Es wurde jedoch nicht das gesamte Multitasking-Szenario modelliert, sondern lediglich die Bearbeitung der Zweitaufgabe
- Kernproblem für ein ACT-R - Model zu MT liegt in der Entscheidung, was den Aufgabenwechsel bestimmt [Kushleyeva et al., 2005]
- Erste vielversprechende Ansätze [Salvucci, 2005; Taatgen, 2005] dazu liegen vor (siehe auch „*Threated Cognition*“)

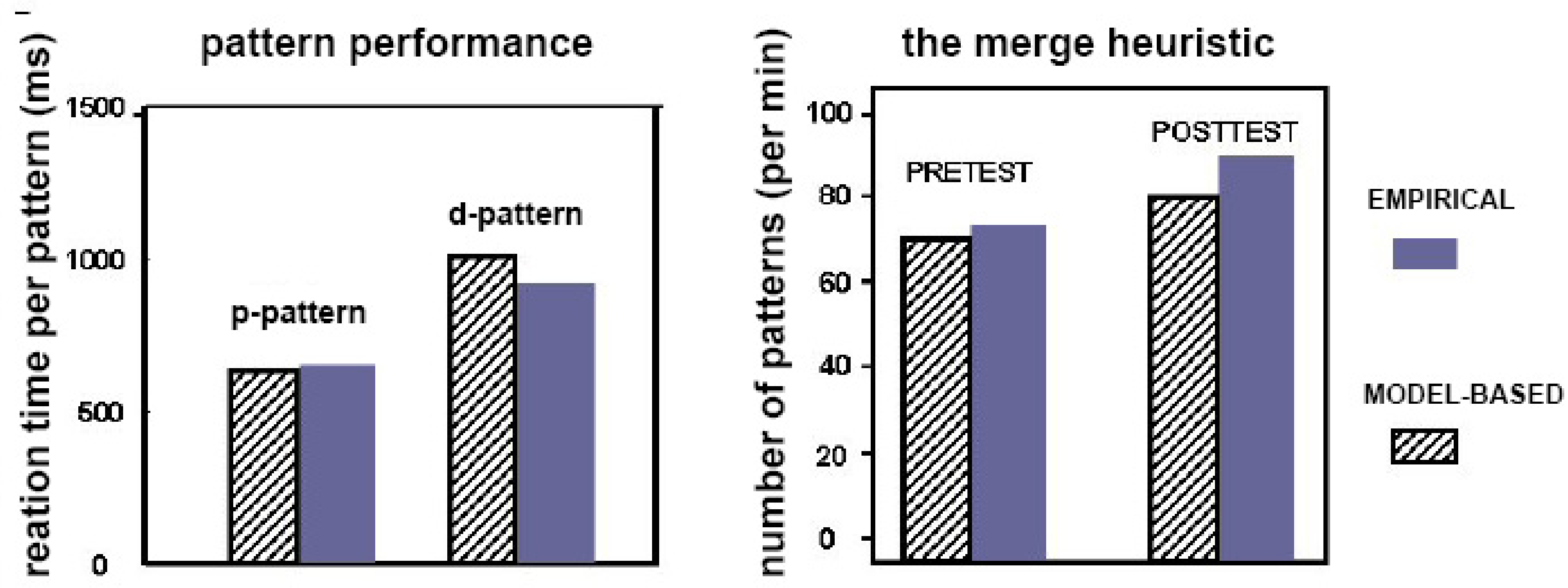


Kognitive

Modellierung

Figure 30. Processing of a single pattern in D2-Drive

Kognitive Modellierung



Taken from: **Kiefer & Urbas [2006]**

Design-Empfehlungen

PROMETEI	Prospektive Mensch-Technik-Interaktion
PROMETHEUS	Der Vorausdenkende & der Schöpfer
PROSPEKTIVE GESTALTUNG	in frühen Phasen der Systementwicklung

1. Erzwinge kein MT (VPN „erlernen“ MT-Heuristiken)
2. Reduziere Komplexität (und erleichtere somit Erlernbarkeit)
3. Nutze Vertrautheitsaspekte (erleichtert die Automatisierung)
4. ... unter Anwendung prospektiver Gestaltung

Kritik und Ausblick

1. *Technische* Beschränkungen (z.B. Eye-Tracking Mess-Probleme)

2. (Prospective) Memory beim MT (*theoretischer Aspekt*)

3. Domain (Un-) Abhängigkeit (*praktischer Aspekt*)

4. (Computationales) Modell zum MT (*Modellierungsaspekt*)

In Greek mythology,

Pandora was the 1st woman. Each god helped create her by giving her unique gifts. Zeus ordered Hephaestus to mold her out of earth as part of the punishment of mankind for **Prometheus** theft of the secret of fire, and all the gods joined in offering this beautiful evil seductive gifts.

According to the myth,

Pandora opened a jar in modern accounts referred to as **Pandoras box**, releasing all the evils of mankind *(greed, vanity, slander, envy, pining)* leaving only hope inside once she had closed it again.

“

if
you find the answer to
1 question,

you open a box to
another
20 questions

“

[Ø]

“ Ich hatte nur diese Zeit “

[Rainer Werner Fassbinder]

[... und Multi-Tasking im **wirklichen** Leben]

Vielen Dank für Ihre

auditorische

visuelle

kognitive

serielle oder parallele

Aufmerksamkeit

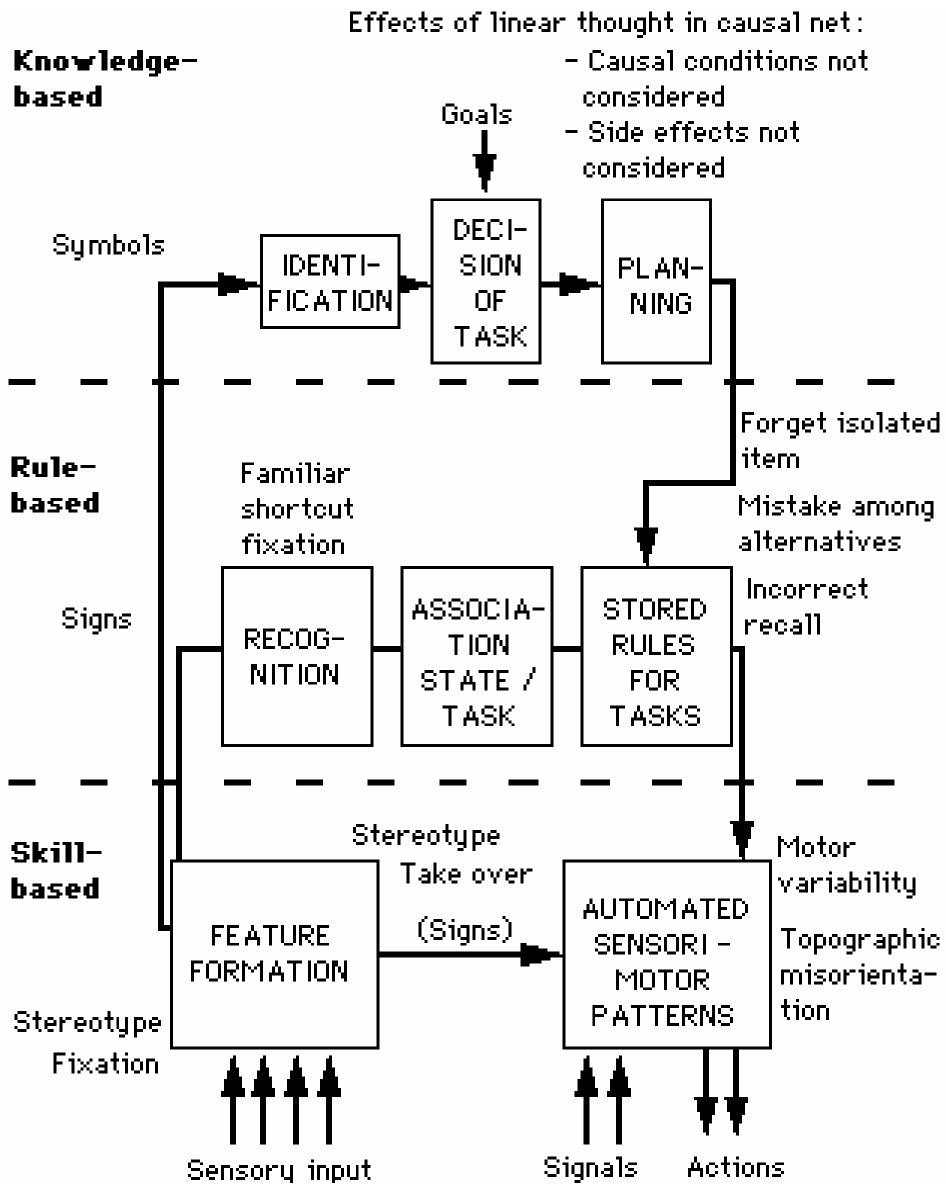
X Anhang

- **Rogers and Monsell** [1995]: **faster in repeating a task** compared to task switching. This is also true for familiar tasks which can easily be anticipated. Given more time between the trials did not help to completely eliminate the switching costs. According to Rogers and Monsell, switch costs are explained by (a) the need for mental control for the new setting, and (b) carry-over effects from the previous trial. Proper preparation did not have any significant improvements.

- **Meuter and Allport** [1999] did a study in which subjects were asked to name digits in their first or second language (depending on the background color). Not surprisingly, response time for digits in the first language was faster compared to the second language (in a repetitive task setting). But also, **subjects were slower when the language changed (task switching).**

- **Rubinstein and Evans** [2001] showed in a serial of four famous studies using a variety of tasks (e.g., maths, geometry) that **task switching causes tremendous time loss.** Additionally they were able to show that performance was strongly influenced by task complexity.

- **Yeung and Monsell** [2003] present a modeling of experimental interactions between task dominance and task switching, illustrating the importance of so-called **prospective memory** (we will come back to that concept later within this work). It seems that remembering where to continue a task plays a key role in the context of task switching.



1. Skill-based behavior (SBB): Automatic processing, without conscious attention or control, relying on signals.

2. Rule-based behavior (RBB): Behavior is based on familiar
rules and consists of a sequence of subroutines (e.g., mathematical problem solvin, driving)

3. Knowledge-based behavior (KBB): Relying upon a "mental model" (of the system), no rules needed.

2.1.6 Skills, rules, and behavior (Rasmussen [1983])

Source of interruption The interruption can be taken by the person who is doing a task (i.e., self, internal interruption), by another person (i.e., external interruption), or by a machine (e.g., computer, external interruption). In many classical studies on task switching, the source of the interruption can easily be controlled, for instance by stopping task one and allowing to fully focus on task two. However, in the context of human multitasking, the situation looks rather different when one ongoing task is not stopped even though a second task starts.

Individual differences Humans are bounded and rely on personal limitations. Cognitive processing is limited, and so are processes of perception and motor response. Individual differences play an important role in the field of human interruption, but are not of deeper interest within this work.

Method of coordination Immediate interruptions occur without coordination, in contrast to negotiated interruption. Further methods are (human- or machine-) mediated interruption and scheduled interruption based on an explicit agreement or by convention for repetitive interruptions.

Meaning of interruption We all know the most common meaning of interruptions in our daily life. Alarms clocks during a meeting remind us to stop the current activity (task) and turn to another task/appointment/ activity. Simply spoken, we are reminded that now, starting with the alert, our attention has to be focused on a specific action. Interruptions can also beckon us to ultimately stop our current task.

Method of expression Physical expression (verbal, paralinguistic, kinesic), expression for effect on face-wants (politeness),a signaling type (by purpose, availability, and effort), metal-level expressions to guide the process, adaptive expression of chains of basic operators, intermixed expression, expression to afford control.

Channel of conveyance

Changed human activity

Effect of interruption

Models of **discrete successive tasks** are task switching studies like those already examined in the 1920‘s. Alternating simple choice-reaction tasks are applied to investigate switching costs.
In these scenarios, the aspect of concurrency is not given.
Models of **discrete concurrent tasks** include a temporal delay. PRP-studies in the context of dual task performance 28 theoretical background belong to this section. Stimulus onset asynchrony defines when the second task begins. As already mentioned before, Pashler [2000] and others assume a central bottleneck which does not allow absolute concurrency.
Elementary continuous tasks build the bridge to multitasking in daily life: one continuous task (e.g., driving) is performed while at some points a discrete task (e.g., a simple choice reaction task) is presented. To the authors belief, integrating these aspects of concurrency is a first step into human multitasking in a realistic context.
Even more important and relevant for this work are **compound continuous tasks.** As the former category refers to tasks with a duration shorter than 10 seconds, this last section captures many scenarios, be it in the context of air traffic control, driving, or mobile computing.

Salvucci proposes an general executive which is

- an architectural mechanism
- dependent on time
- sensitive to goal representations

Deciding when to switch:

1. the ability to create and schedule future intentions
2. the facility to remember and prioritize these intentions
3. the ability to switch from carrying out one to another task when the appropriate moment in time is finally reached

Salvucci mentions *"natural breaking points"* necessary for interleaving tasks. He proposes two core heuristics to decide when to switch between goals, namely

- the iterating heuristic: Salvucci gives the example of a task with a duration of 100 sec, assuming 50msec per production rule, so in sum 2.000 rules to fire. When the model returns to a previous fired rule, task switching should be proposed at this point. The next iteration is initiated by a new goal. Especially for models with a long duration in terms of execution time, this heuristic becomes plausible.

- the blocking heuristic: Salvucci mentions "significant time" and the problem how to decide about that. He illustrates that for perceptual motor actions (PM) in particular, ACT-R has to wait until an action is done. In such a case, the blocking heuristic proposes to create a new goal which gives permission to a secondary task to intercede.

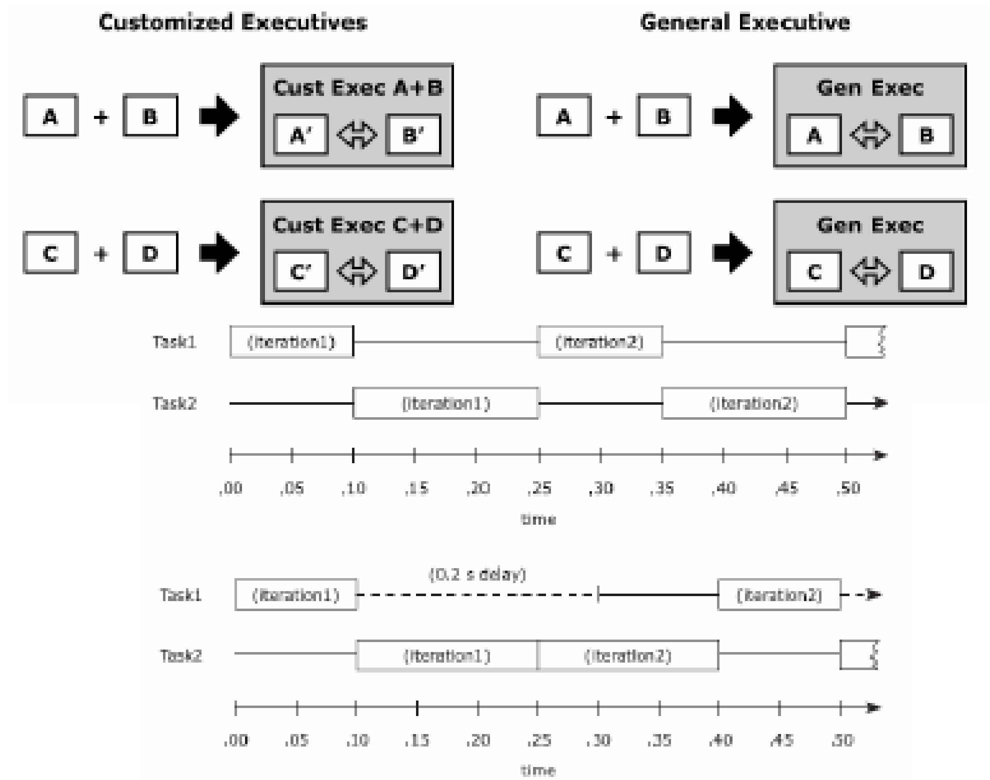


Figure 34. Overview of multitasking general executive proposed by Salvucci [2005]

- A cognitive processor manages the concurrency of multiple goals at the same time.
- As in earlier frameworks of ACT-R, only one goal can be executed at the same time.
- Goal switching is moderated by heuristics.

- Urgency defines when to switch to which goal.

I: Identifizierung von MT-Heuristiken

Wie verhalten sich Personen in alltagsnahen Situationen unter MT?

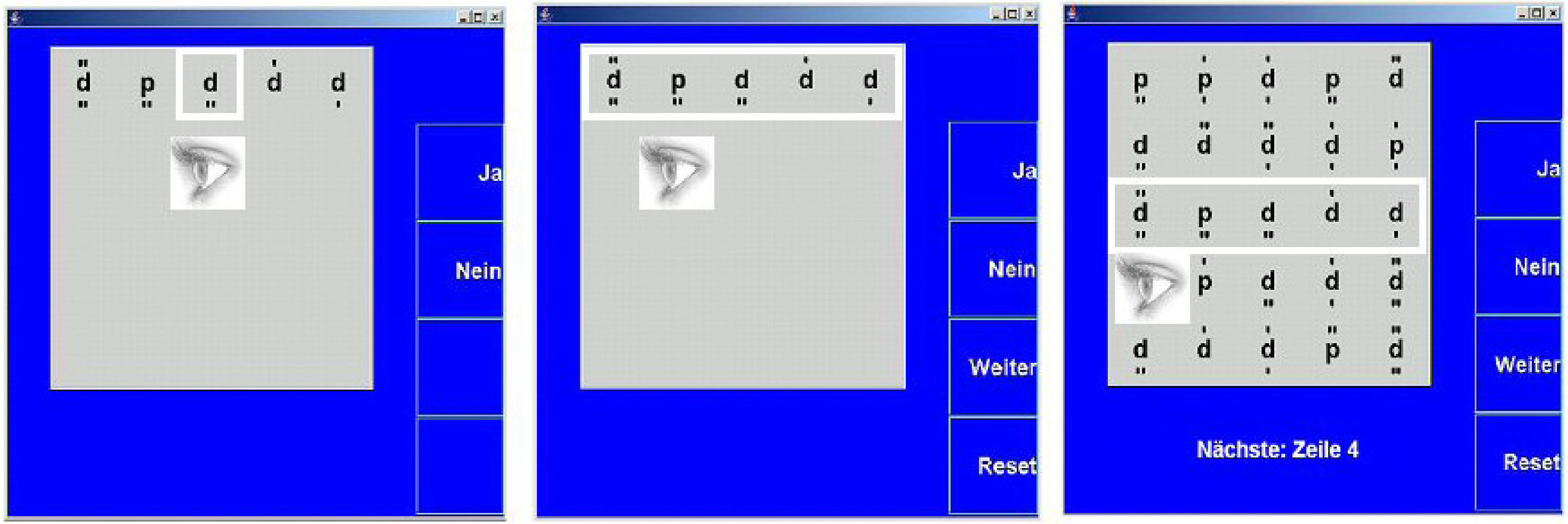
N=24
Primary task in study I was a driving task: participants were asked to drive with constant speed (130 km/h) in a driving simulation in a car.

The task itself was quite trivial (keeping the lane).

- Attention: D2-Drive requires full visual attention.
- Access: D2-Drive can easily be learned.
- Interruptability: D2-Drive can be interrupted and resumed.
- Resources: D2-Drive is a measuring tool for residual resources.
- Cognition: D2-Drive requires perception (read), cognition (decide) and action (motor response).

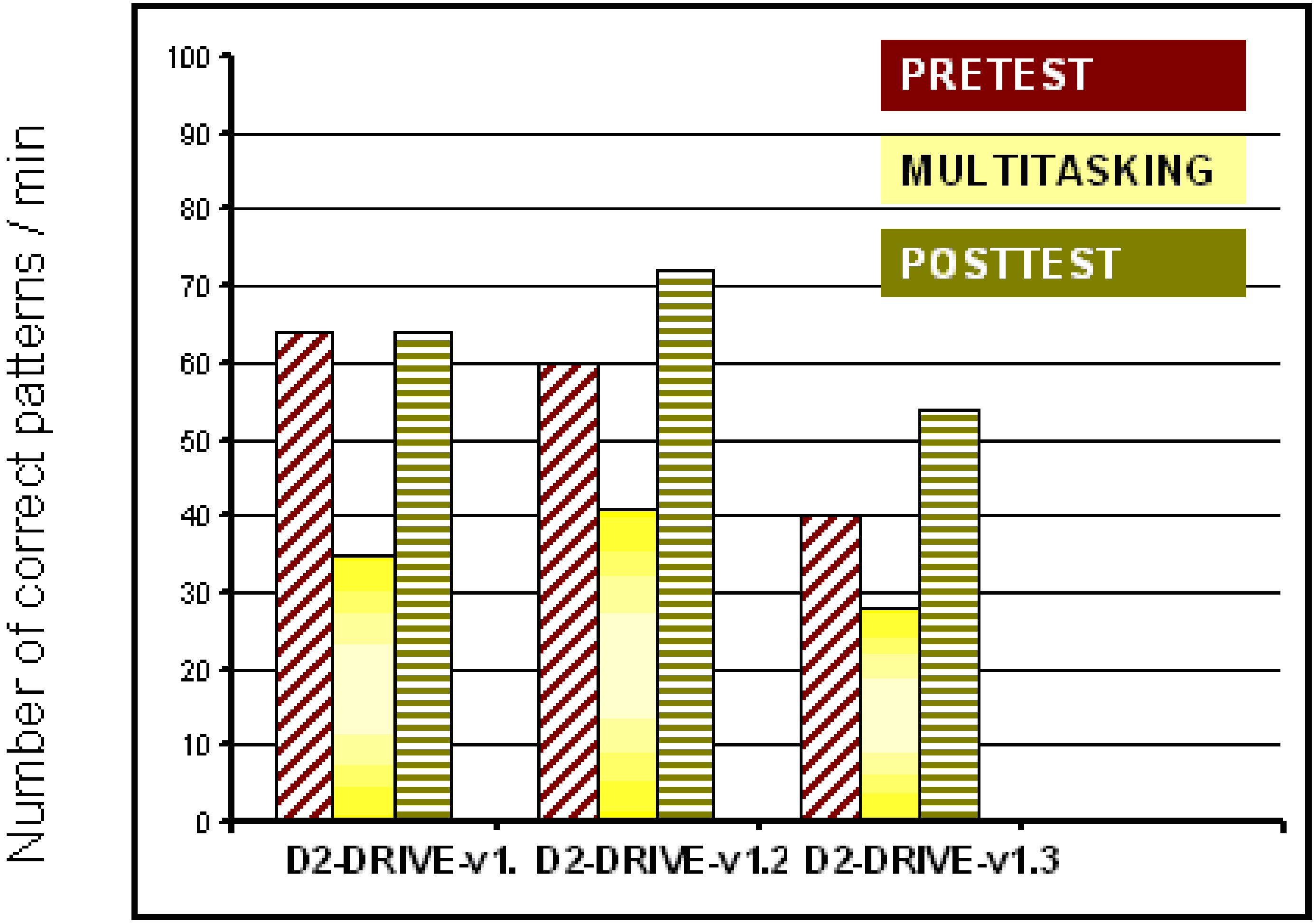
d2-drive-v1.1: Presentation of a complete row of (five) patterns Focus only on the pattern in the middle (third pattern) Execution only of pattern in the middle (1 pattern)
d2-drive-v1.2: Presentation of a complete row of (five) patterns Focus on complete

d2-drive-v1.3: Presentation of a matrix of patterns (rows and columns) Focus on the row whose number was presented Execution of this complete row



Complexity of **D2-Drive** was treated as *between-subjects factor* (three groups with 8 participants per version) and **condition** (single- vs. multitasking) as *within-subject factor*.

1. Welcome, introduction and instruction
2. Training "Driving“, 1lap
3. Baseline "Driving“, 1lap
4. Training "D2-Drive“, 1min
5. Single-Task "D2-Drive" (Pretest) (3 Versions, system. Var.)
6. Dual-task session (4 x "D2-Drive")
7. Single-Task "D2-Drive" (Posttest) (3 Versions, system. Var.)
8. Structured interview



3.1 study i: Results

II: Auswirkungen von Übung auf MT

Welche Auswirkungen haben Übung und Aufgabenwiederholung auf die Leistung unter MT?

- Replication of Study I
  same primary task (driving simulator)
  same secondary task (D2-Drive-v1 – D2-Drive-v3)

Extension:

1. Providing more training by extensive driving (2 laps)
2. Impact of pattern length in the D2-Drive (5 vs. 9 patterns)

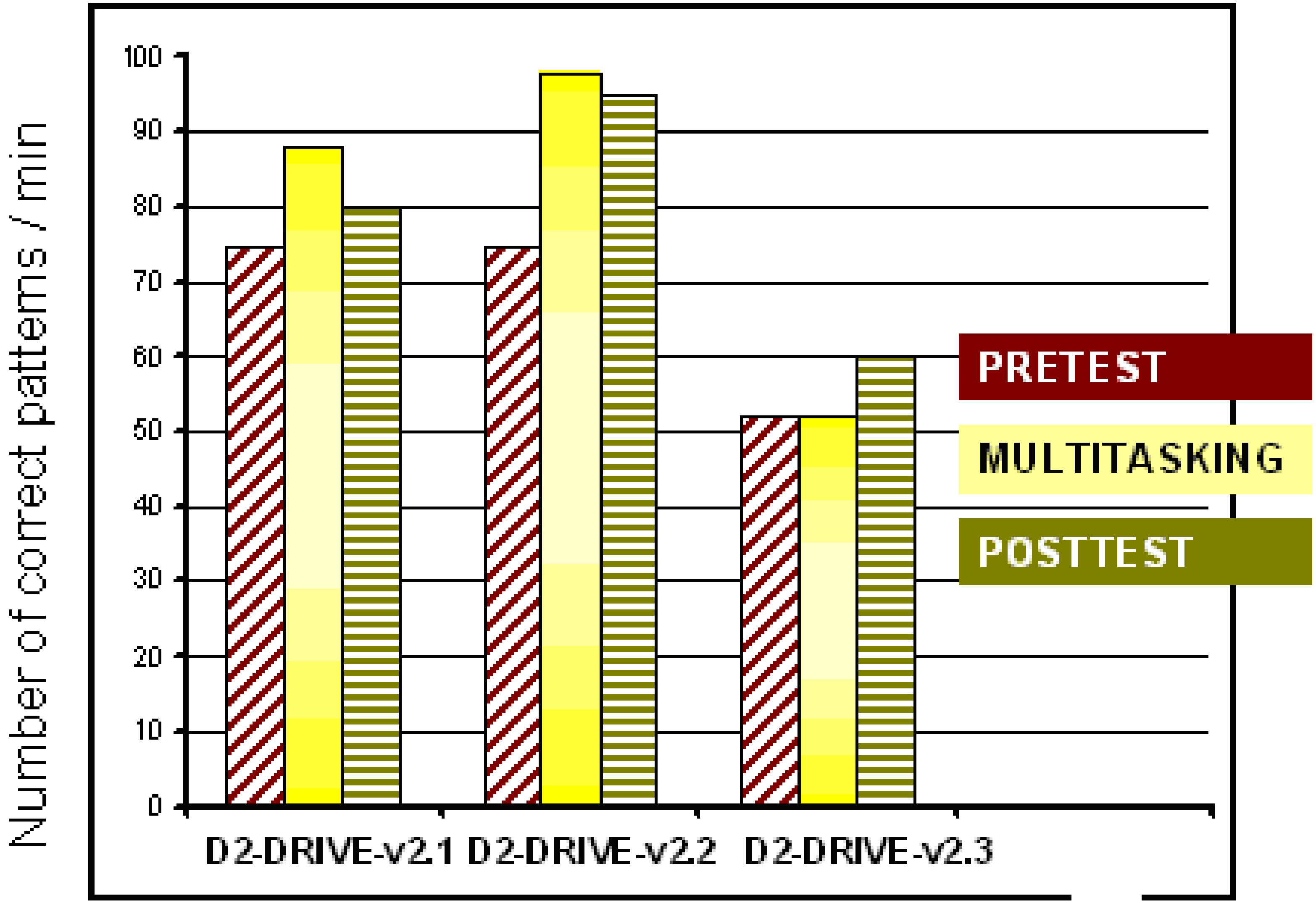
Hypothesis: Intensive driving under multitasking

In the previous study, driving performance was not influenced by multitasking. Therefore, in study II no significant differences were expected under multitasking compared to driving in the single task condition. The instruction (i.e., considering driving as man task with main priority) was expected to fully work, meaning that participants should perform D2-Drive without neglecting the driving task.

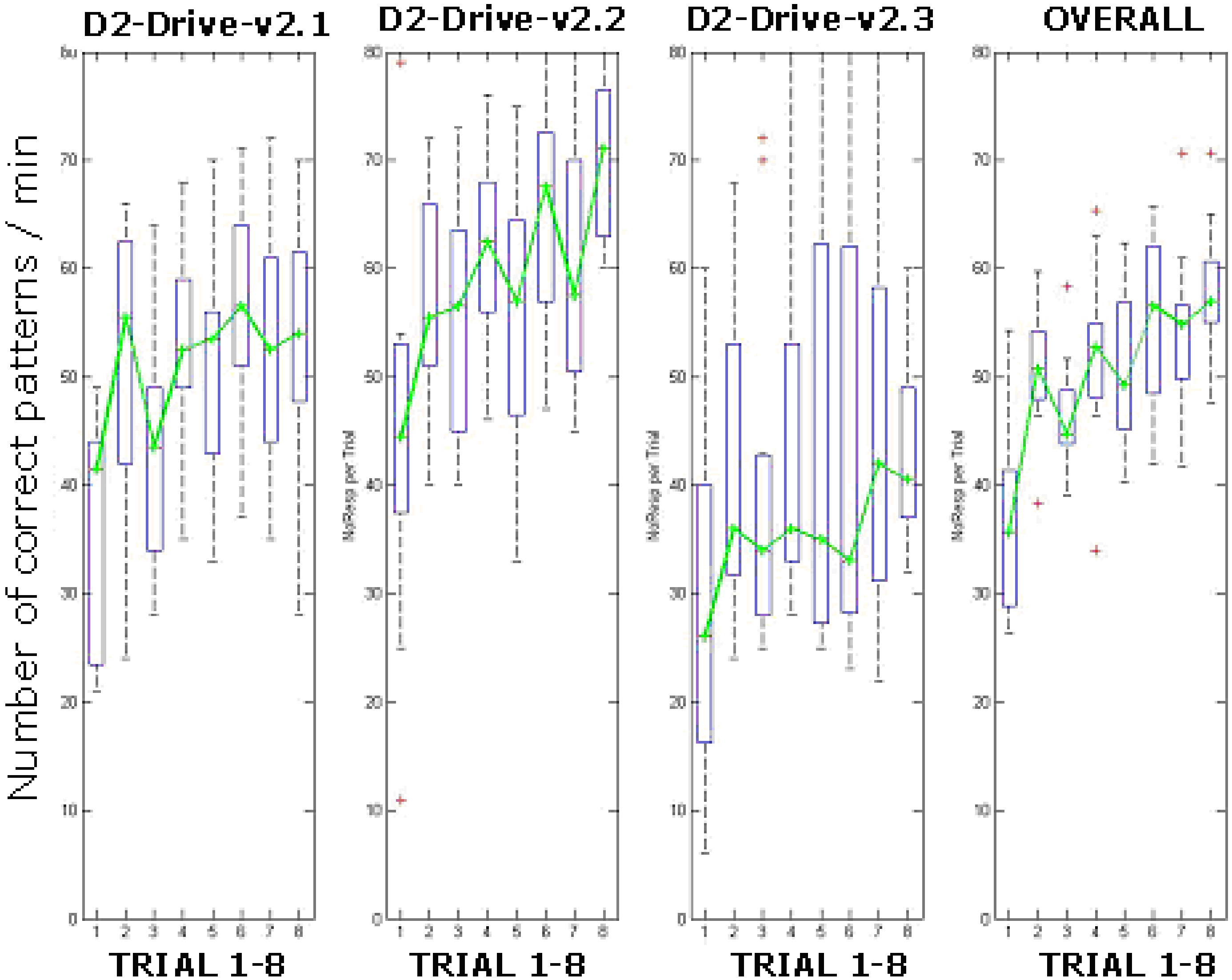
D2-Drive under multitasking (pattern lengths and practice)

Intensive training should thus promote using the "merge heuristic" (consciously as well as unconsciously) and thus lead to a better performance for D2-Drive-v2.2, but not for D2-Drive-v2.1 (due to its configuration not supporting the use of the described heuristic).

1. Welcome, introduction and instruction
2. Training "Driving“ (1lap)
3. Baseline "Driving“(1lap)
4. Training "D2-Drive“, 1min
5. Single-Task "D2-Drive" (Pretest), 1min
6. Dual-task session (4 x "D2-Drive", lap 1)
7. Dual-task session (4 x "D2-Drive", lap 2)
8. Single-Task "D2-Drive" (Posttest), 1min
9. Structured interview



3.2 study ii: practice supporting multitasking heuristics


D2-Drive-v2.1
D2-Drive-v2.2
D2-Drive-v2.3
OVERALL
Number of correct patterns / min
TRIAL 1-8
TRIAL 1-8
TRIAL 1-8
TRIAL 1-8

Main Findings of STUDY II:

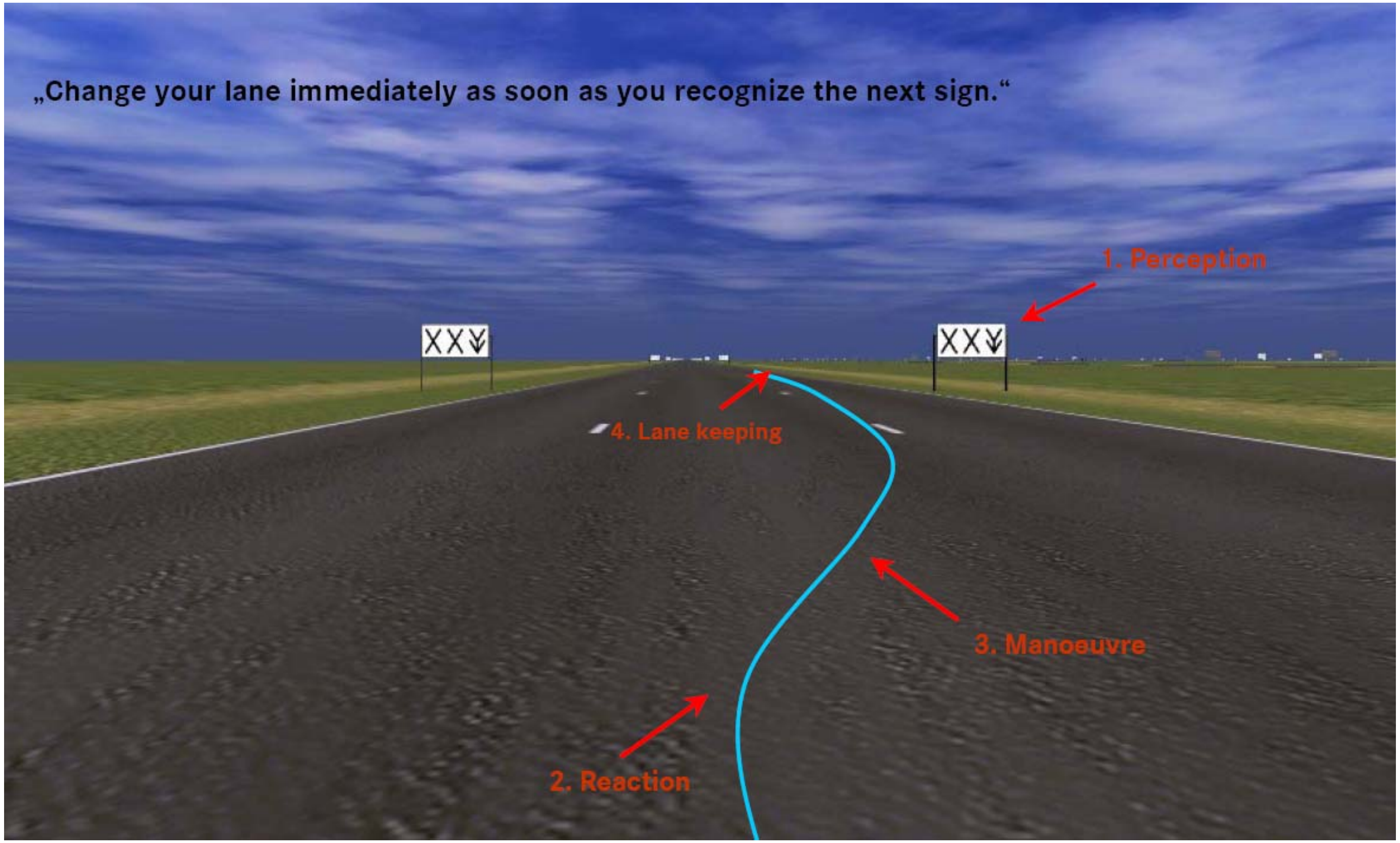
1. Practice supports the development of cognitive heuristics.
2. Task complexity seems to have an decisive influence.
3. Different task configurations require different amounts of visual attention.
4. The driving task (tracking) remains unaffected by the secondary task.

VERSION OF D2	GAZES ON D2-DRIVE	GAZES ON LANE
Total	47 percent	51 percent
D2-Drive-v1.1	48 percent	51 percent
D2-Drive-v1.2	35 percent	62 percent
D2-Drive-v1.3	48 percent	51 percent

Table 2. Study II: Amount of attention (eye gazes, AOI)

III: Aufgabenkonfiguration und MT

Wie wirkt sich die Aufgabenkonfiguration auf das Verhalten unter MT aus?



3.3 study iii: the role of task configuration – Main Task

Secondary task in study III (n=40) was a systematic variation of D2-Drive-v1.2 (i.e., D2-Drive-v2.2) with the following features:

- d2-drive-v3.1	Constant row, no visual support
- d2-drive-v3.2	Changing row, no visual support
- d2-drive-v3.3	Constant row and visual support
- d2-drive-v3.4	Changing row and visual support

- In contrast to the previous two studies, complexity of D2-Drive was treated as within-subjects factor.

- To avoid learning effects, the order of the D2-Drive versions was balanced.

- The condition "single- vs. multitasking" was also treated as within-subject factor.

Independence of primary task (stability)

As in the previous two studies, in study III driving is expected to remain stable under multitasking as it is instructed as primary task. No performance decrease is expected. Same counts for lane change behavior: as an effect of proper instruction and training, participants should not produce errors (i.e., assuming the constantly change to the correct lane).

Influence of task configuration

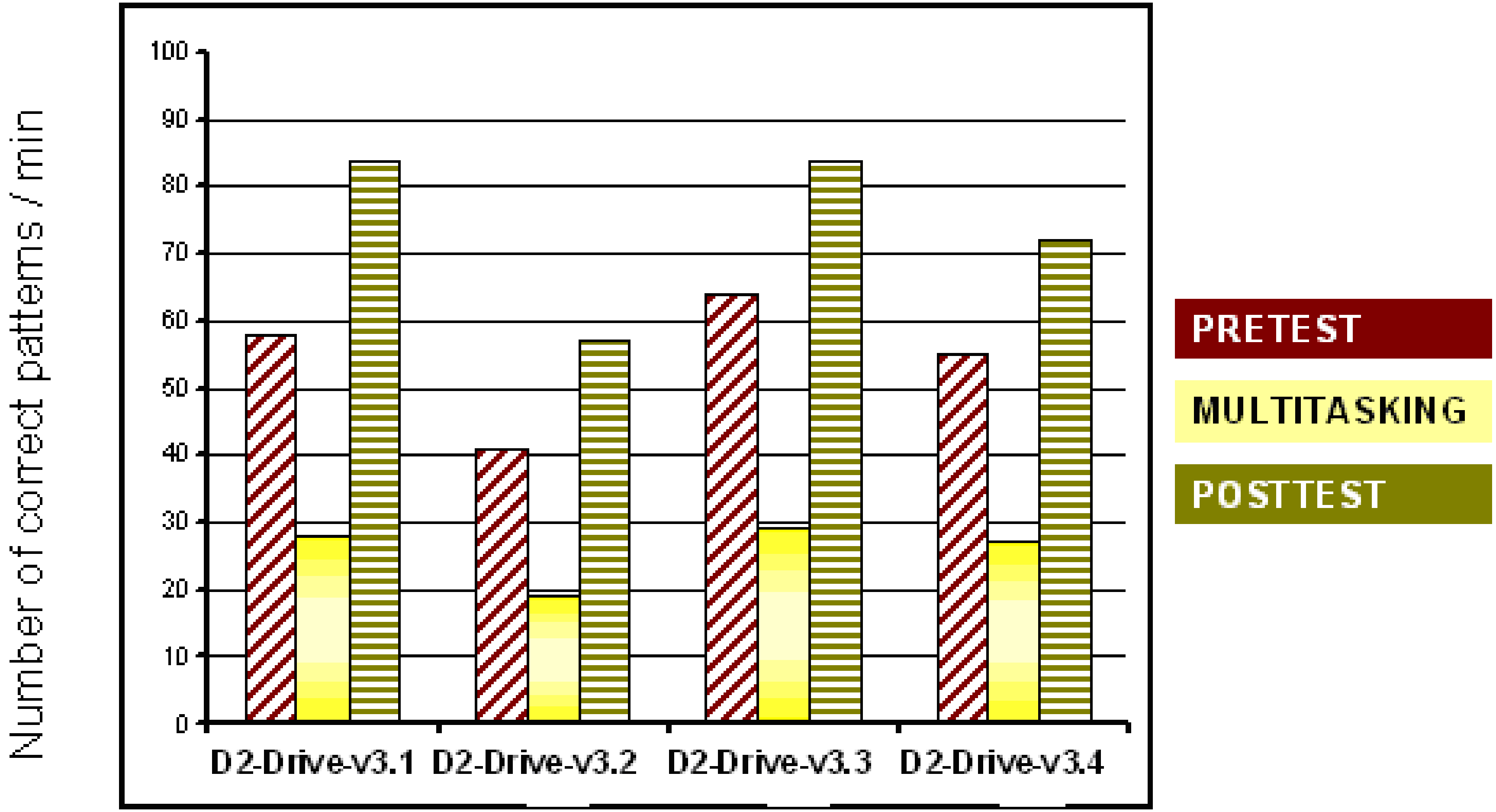
The investigated main task in study III contains higher cognitive demands than the main tasks in the previous two studies. For this reason, performance in D2-Drive under multitasking is expected to strongly decrease under multitasking in comparison to single task performance. In D2-Drive-v3.1 and D2-Drive-v3.3, the pattern row does not change which offers the possibility to apply the "merge heuristic": responses can be anticipated and entered in a unit of several patterns. During this action (motor response), visual resources are "free" and participants can scan the lane and (visually) resume the primary task, i.e. driving.

01. Welcome and general introduction
02. Introduction of LCT
03. Training "Driving" (LCT), 1round
04. Single task "Driving" (LCT, Baseline), 1round
05. Introduction and Training "D2-Drive-v3.1“, 1min
06. Single task "D2-Drive-v3.1" (Pretest) , 1min
07. Introduction and Training "D2-Drive-v3.2", 1min
08. Single task "D2-Drive-v3.2" (Pretest) , 1min
09. Introduction and Training "D2-Drive-v3.3", 1min
10. Single task "D2-Drive-v3.3" (Pretest) , 1min
11. Introduction and Training "D2-Drive-v3.4", 1min
12. Single task "D2-Drive-v3.4" (Pretest) , 1min
13. Introduction to eye tracking measuring
14. Checking of eye tracking system
15. Dual task (session) (including "D2-Drive-v3.1" - "D2-Drive-v3.4"
16. Single task "D2-Drive-v3.1" (Posttest)
17. Single task "D2-Drive-v3.2" (Posttest)
18. Single task "D2-Drive-v3.3" (Posttest)
19. Single task "D2-Drive-v3.4" (Posttest)
20. Structured interview

05-12 system. variation

Results: Eye tracking

D2.Drive-vrs.	Gazes at *LCT*	Gazes at D2-Drive	Gazes at Environment
D2-Drive-v3.1	60	35	5
D2-Drive-v3.2	44	51	5
D2-Drive-v3.3	71	26	3
D2-Drive-v3.4	50	46	4


Number of correct patterns / min
100
90
80
70
60
50
40
30
20
10
0
D2-Drive-v3.1
D2-Drive-v3.2
D2-Drive-v3.3
D2-Drive-v3.4
PRETEST
MULTITASKING
POSTTEST

In study III,

• performance in primary task (LCT) is not affected by multitasking

• performance in secondary task (D2-Drive) is highly influenced by the presence of a higher demanding primary task (LCT)

• configuration of secondary task (D2-Drive) effects performance, even though this influence reduces under multitasking

• configuration of secondary task (D2-Drive) strongly influences multitasking heuristic

X end