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The Influence of Ego Depletion on Learning

- with Inference Prompts vs. no Prompts

- under Self-paced vs. System-paced conditions

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Cognitive Load Theory

(CLT; e.g., Sweller, Ayres, & Kalyuga, 2011; Paas & Sweller, 2014)

Limited capacity of Working Memory:

- avoiding/reducing unnecessary load in working memory (i.e., Extraneous Cognitive Load [ECL]↓)
- dedicating working memory to active processing of content
  → investing germane resources

→ prompting learners to actively process information

Engaging in active learning

(cf. Bjork & Bjork, 2011; Fiorella & Mayer, 2015; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013)

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For instance…

- self-explanations (cf. Wylie & Chi, 2014)
- self-generated drawings (cf. Leutner & Schmeck, 2014)
- generation effect (cf. Bertsch, Pesta, Wiscott, & McDaniel, 2007)
- inference prompts (e.g., Roelle, Berthold, & Renkl, 2014; cf. Renkl, 2011)
  - learners are prompted to generate specific inferences that are crucial for understanding central aspects of a content

Cognitive Load Theory

(CLT; e.g., Sweller, Ayres, & Kalyuga, 2011; Paas & Sweller, 2014)

Limited capacity of Working Memory:

→ avoiding/reducing unnecessary load in working memory (i.e., Extraneous Cognitive Load [ECL]↓)

→ dedicating working memory to active processing of content
→ investing germane resources

→ for active processing: learners need the resources available

- one potentially important factor with respect to available resources: the role of Self-Control (e.g., Baumeister, Vos, & Tice, 2007)

Self-Control & Ego Depletion

(e.g., Baumeister, 2014; Baumeister, Vohs, & Tice, 2007)

Self-Control:

- the deliberate, conscious, effortful subset of self-regulation
- is necessary to carry out higher order (cognitive) processes
- depends on a limited energy resource that can be depleted by acts of Self-Control (analogy: like a muscle gets tired)

- when depleted by a first task of Self-Control (e.g., effortful suppression of an impulse; inhibiting habits) → poorer performance on a second task involving Self-Control

Ego Depletion:

- reduced capacity for further self-regulation due to prior exertion of Self-Control (by a previous task)

Ego Depletion - Empirical Findings

Meta-analysis (Hagger, Stiff, Wood, & Chatzisarantis, 2010):

- medium to large overall effect of Ego Depletion on the second task (d = 0.62)
  - controlling impulses (d = 0.71)
  - subjective fatigue (d = 0.44)
  - motivation (d = 1.05)
  - cognitive processing (d = 0.48)

Ego Depletion – Empirical Findings on Cognitive Processing

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poorer intellectual performance under ego depletion, e.g.:

- reading comprehension (e.g., Schmeichel, Vohs, & Baumeister, 2003)
- reasoning tasks (e.g., Fennis, Janssen, & Vohs, 2009; Schmeichel et al., 2003)
- mental arithmetic task (e.g., Johns, Inzlicht, & Schmader, 2008)
- …

Ego Depletion & Working Memory (WM)

Impact of Ego Depletion on WM: unclear

- poorer performance on WM tasks (Schmeichel, 2007)
- no differences (Lurquin, Michaelson, Barker, Gustavson, von Bastian, Carruth, & Miyake, 2016)
- dependent on similarity of depletion tasks and WM task (Healey, Hasher, & Danilova, 2011)

Ego Depletion and Active Learning

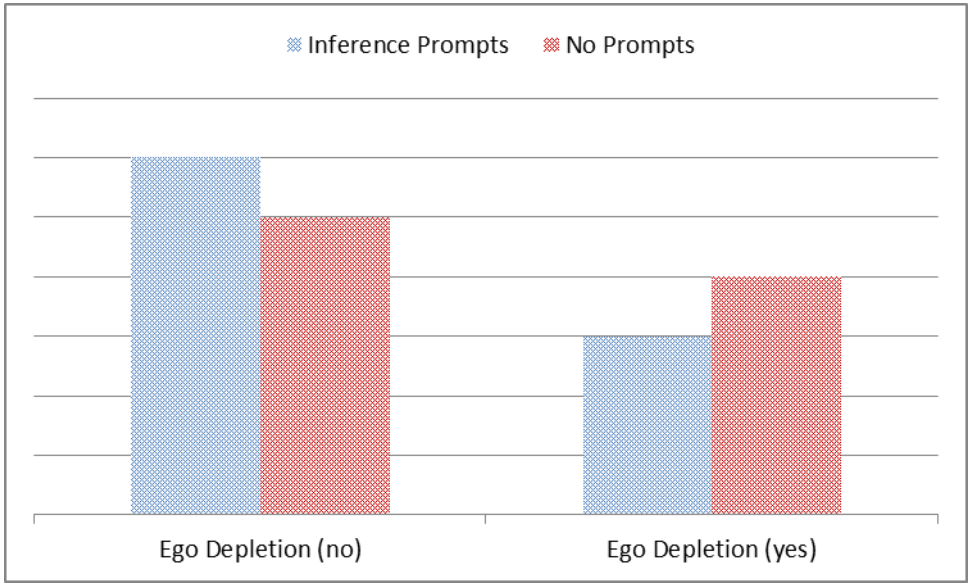
Ego Depletion can hamper higher order information processing

Engaging learners in active processing (e.g., generating information via inference prompts) might

- be beneficial under normal (nondepleted) conditions (when germane resources can be invested)
- backfire under conditions of ego depletion
  → overwhelming learners (no germane resources)

Hypotheses & Research Questions

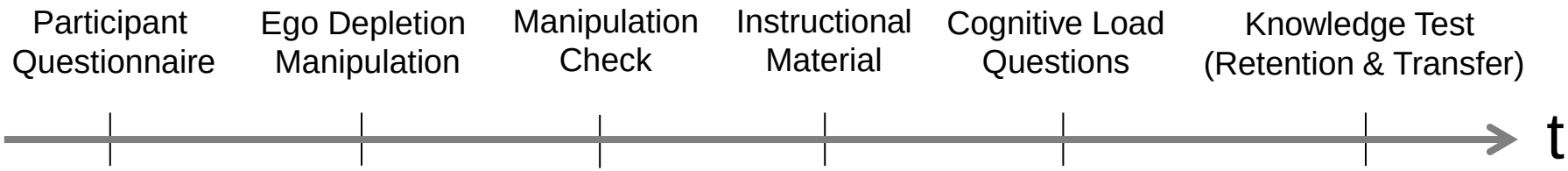
1) Learning under Ego Depletion leads to poorer performance
2) Interaction of Learning Condition & Ego Depletion
   - nondepleted: inference prompts > no prompts
   - Ego Depletion: inference prompts < no prompts



2x2-Design

N=97 participants (56 female; age: *M* = 21.75, *SD* = 2.03)

Instructional Material	Ego Depletion: Yes	Ego Depletion: No
Inference Prompts	n=26	n=23
No Prompts	n=23	n=25



Ego Depletion Manipulation

Writing task (Bertrams, Englert, Dickhäuser, & Baumeister, 2013):
Transcribing a text on a blank sheet (6 min.)

Manipulation:

- No Ego Depletion: usual transcription
- Ego Depletion: omit the letters *e* and *n* wherever they would normally appear in the transcription:
  e.g.: *participats i th dpltio coditio wr istructd to omit th lttrs **e** ad **n***

- Manipulation Check: 3 items asking for Exhaustion, Difficulty and Suppression (of usual writing behavior)
  → "Depletion-Score"

Instructional Material – Excerpt

("How airplanes achieve lift"; Mautone & Mayer, 2001; Eitel & Kühl, 2016)

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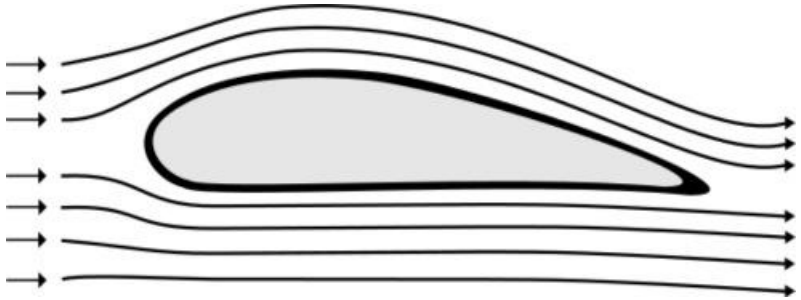
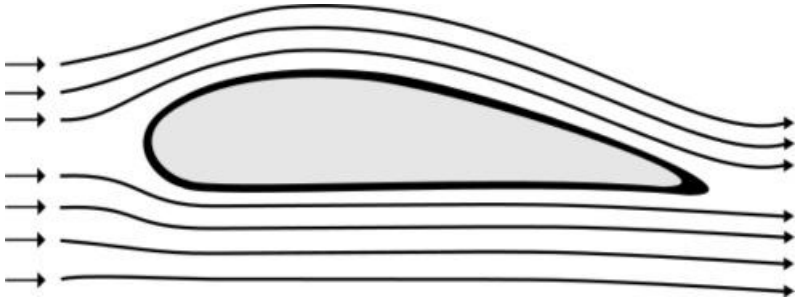
No inference Promt (Text)



The air hitting the front of the wing separates. Some air flows over the wing and some flows under the wing. The air meets up again at the back of the wing at the same time.

The air flowing over the top of the wing has a longer distance to travel in the same amount of time as the air flowing under the wing. As a result, air traveling over the curved top of the wing flows faster than the air that flows under the bottom of the wing.

Inference Prompt



The air hitting the front of the wing separates. Some air flows over the wing and some flows under the wing. The air meets up again at the back of the wing at the same time.

When comparing the air flowing over the top to the air flowing under the wing:

a) Which airflow has a longer distance to travel?

b) What does this mean for the speed of the air traveling over the wing compared to the speed of air traveling under the wing?
(Consider that the upper and lower airflow meet up again at the end of the wing at the same time.)

_____

_____

Subjective Ratings of Cognitive Load

Scales from 1 to 7

Mental Effort:

- *„How much effort did you invest in order to understand the content?“* (Paas, 1992)

Difficulty:

- *„How difficult was it for you to learn with the material?”*

Knowledge Tests

Retention (1 question; cf. Mautone & Mayer, 2001; Eitel & Kühl, 2016):

- *"Please write down as much as you can remember about how airplanes achieve lift...."*

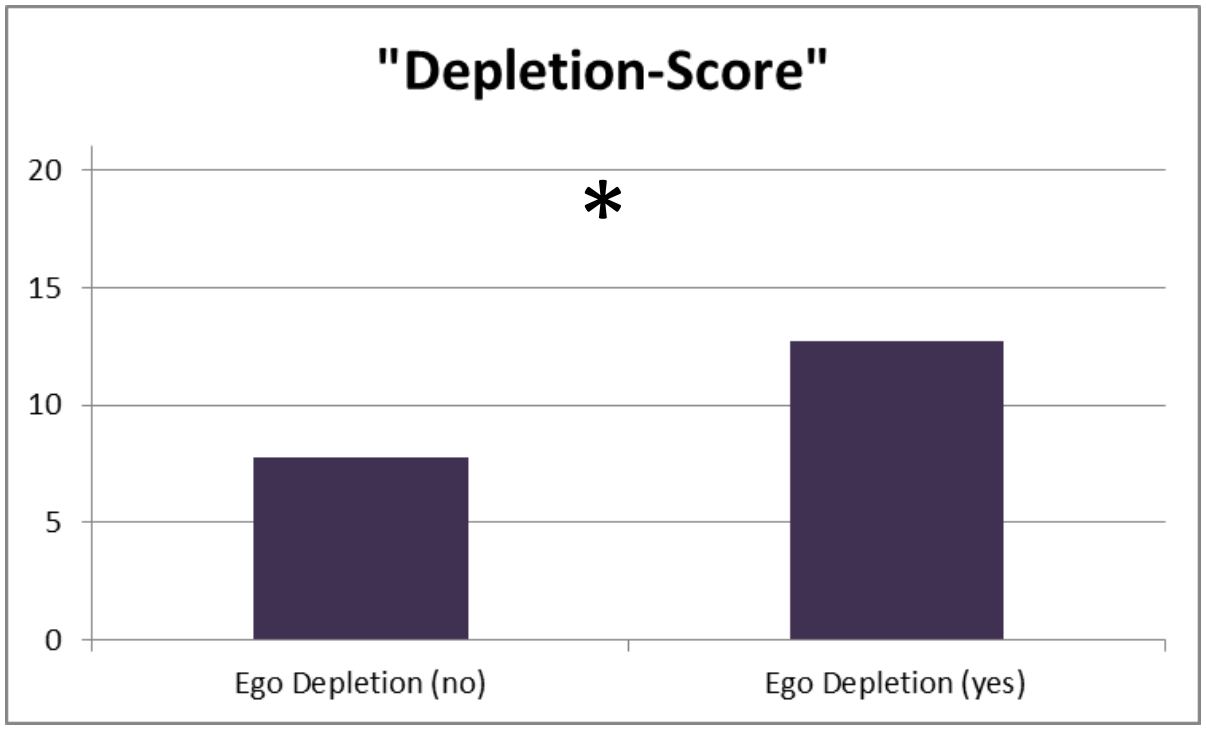
Transfer (4 questions; cf. Mautone & Mayer, 2001; Eitel & Kühl, 2016):

- *e.g., "How could an airplane be designed to achieve lift more rapidly?"*

Results – Manipulation Check

Manipulation-Check Ego Depletion

$t(95) = 7.86$, $p < .001$

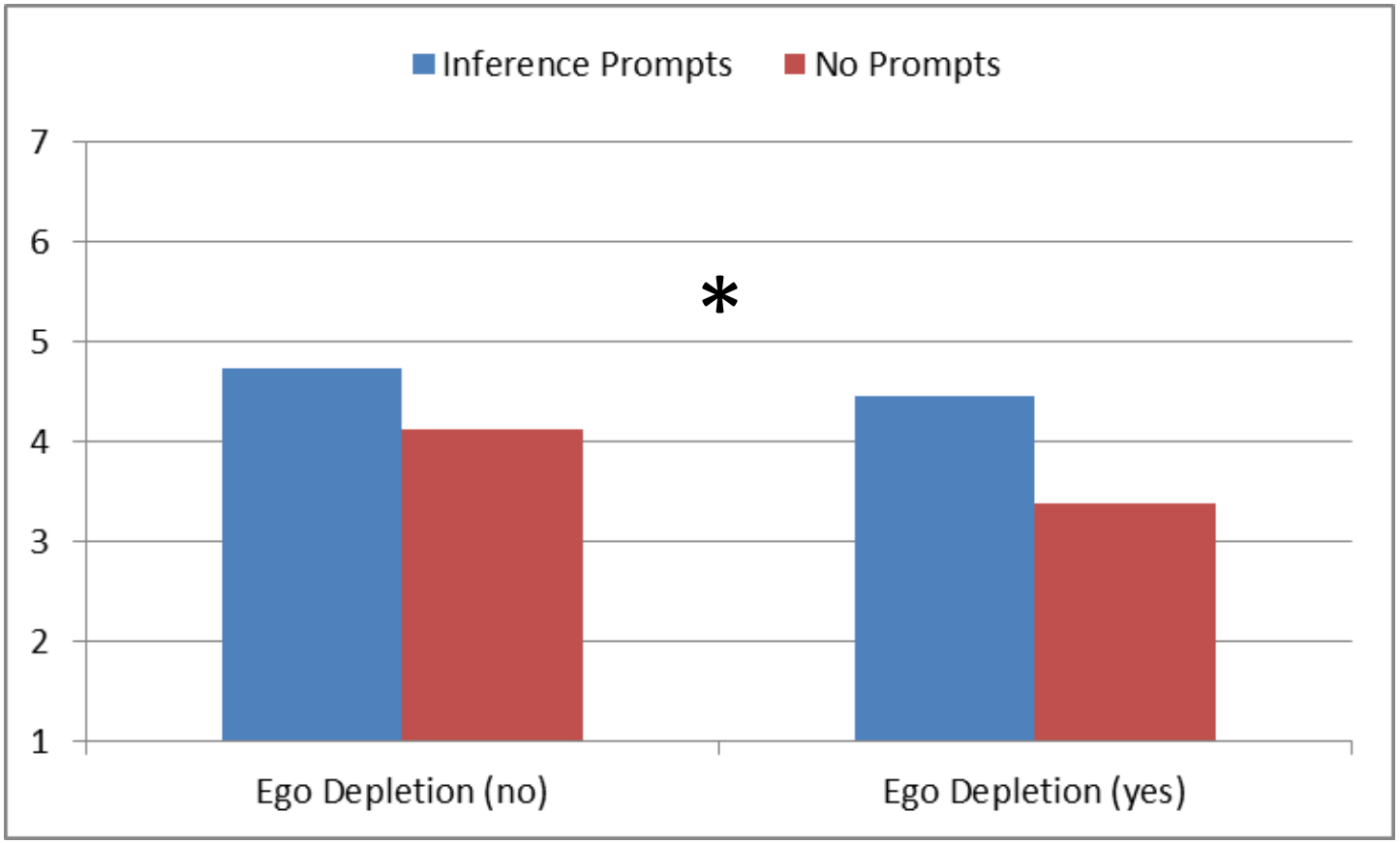


Results – CL: Effort

Main effect EgoDep:
$F(1, 93) = 2.03$,
$p = .16$, $\eta^2_p = .021$

Main effect Prompts:
$F(1, 93) = 5.71$,
$p = .02$, $\eta^2_p = .058$

Interaction EgoDep x Prompts:
$F < 1$, *ns*

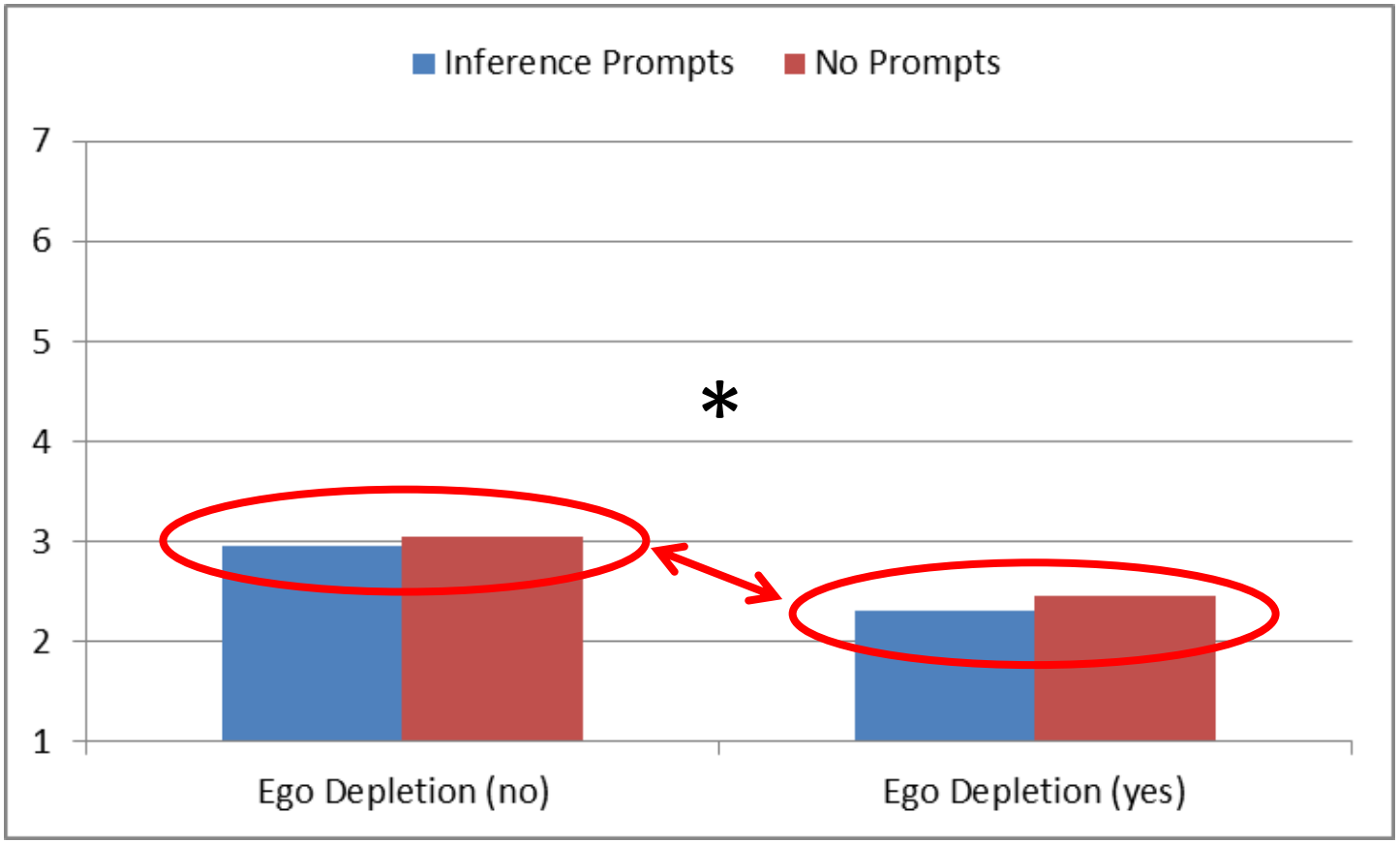


Results – CL: Difficulty

Main effect EgoDep:
$F(1, 93) = 4.12$,
$p = .045$, $\eta^2_p = .042$

Main effect Prompts:
$F < 1$, *ns*

Interaction EgoDep x Prompts:
$F < 1$, *ns*

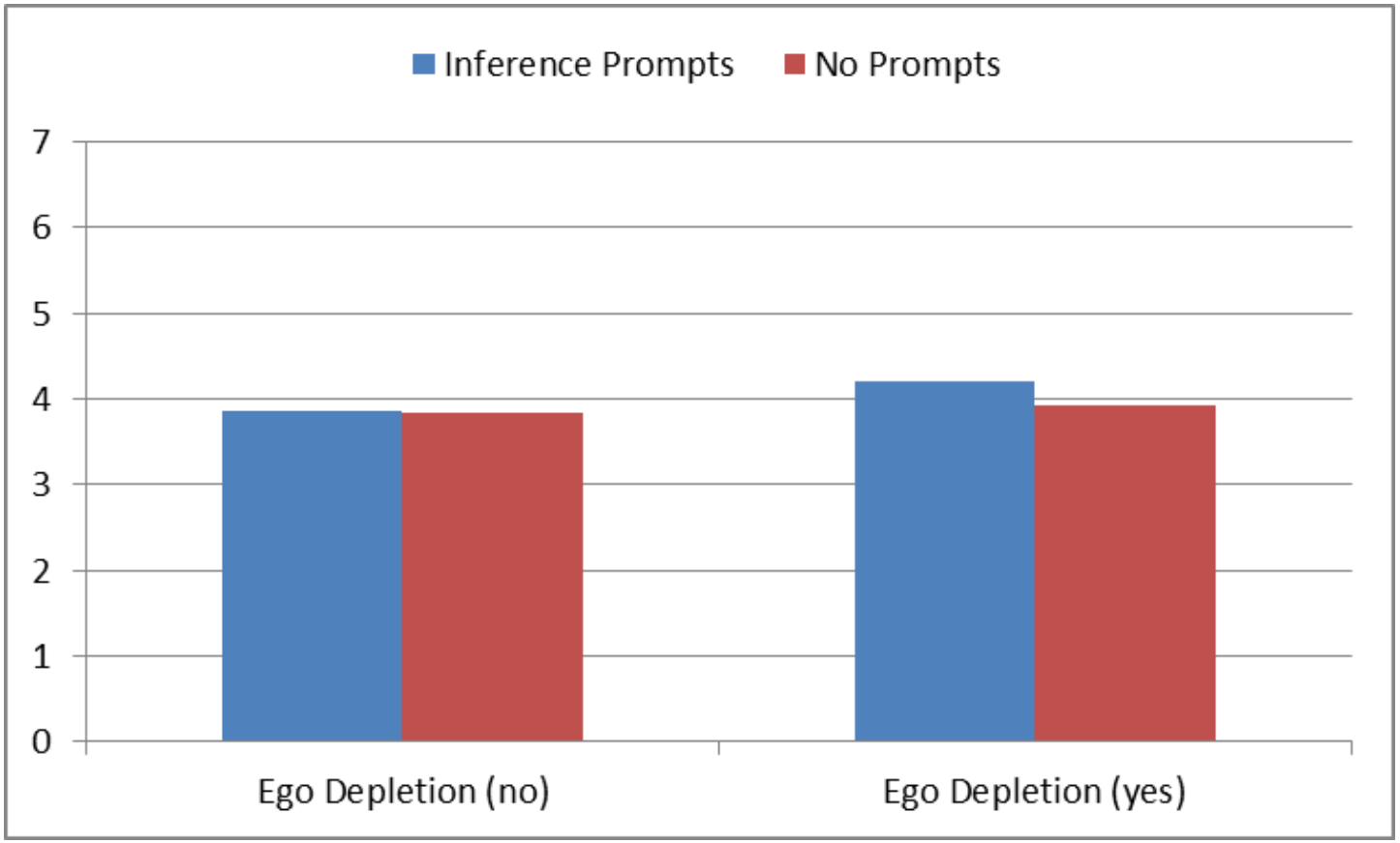


Results - Retention

Main effect EgoDep:
F < 1, *ns*

Main effect Prompts:
F < 1, *ns*

Interaction EgoDep x Prompts:
F < 1, *ns*

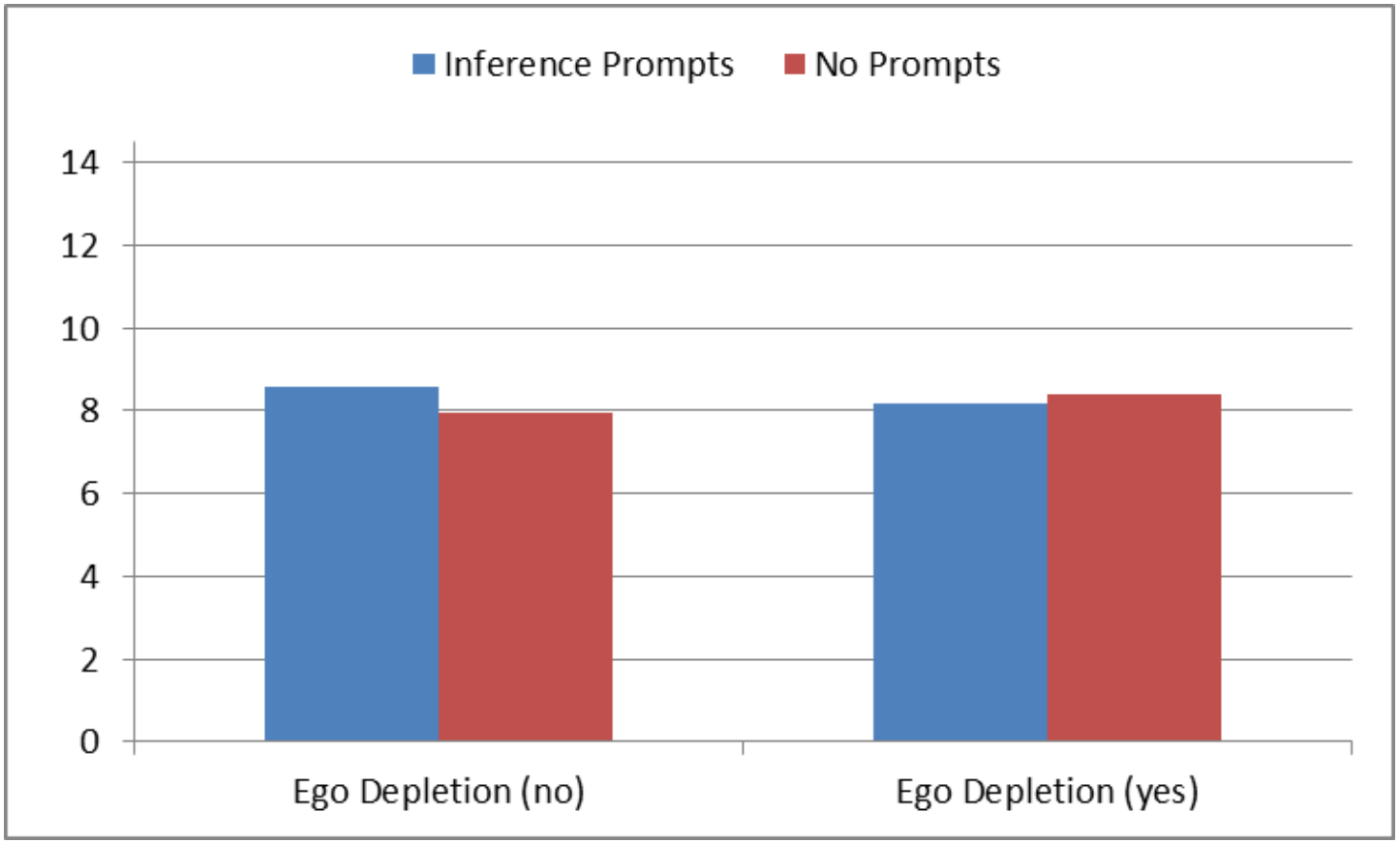


Results – Transfer

Main effect EgoDep:
F < 1, *ns*

Main effect Prompts:
F < 1, *ns*

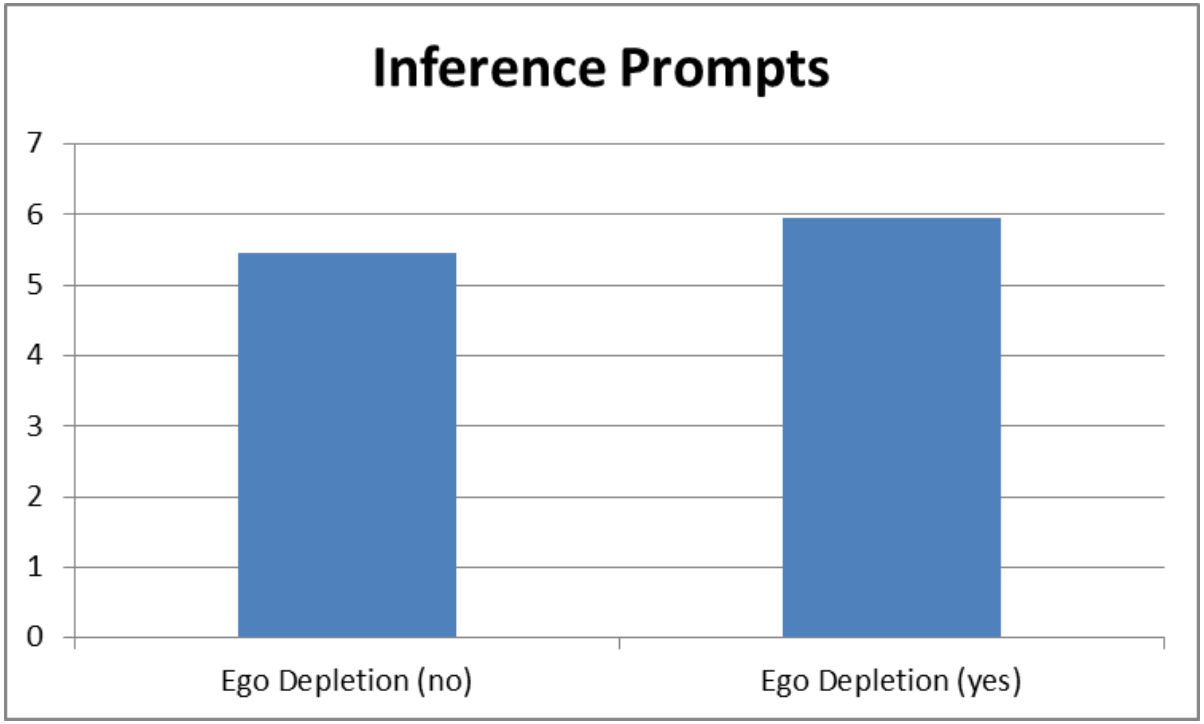
Interaction EgoDep x Prompts:
F < 1, *ns*



Results – Inference prompts

Correct responses to prompts during learning:

$t(32.68) = 1.33,\ p = .19$



positive correlation with retention ($r = .40$, $p < .01$) and transfer ($r = .29$, $p < .05$)

Summary & Discussion

- Manipulation-Check: higher Depletion-Score
- Ego Depletion (vs. no Ego Depletion)
  - lower perceived difficulty in depleted condition?!
  - no influence on mental effort
  - no effect on answering Inference Prompts
  - no influence on learning outcomes
- Inference Prompts (vs. no Prompts)
  - more invested mental effort when learning with Inference Prompts
  - no differences for perceived difficulty
  - answers moderately correlated with learning outcomes
  - no differences for learning outcomes

Discussion

- Inference Prompts: no better results in an immediate knowledge test
  → delayed testing? (cf. Bjork & Bjork, 2011)

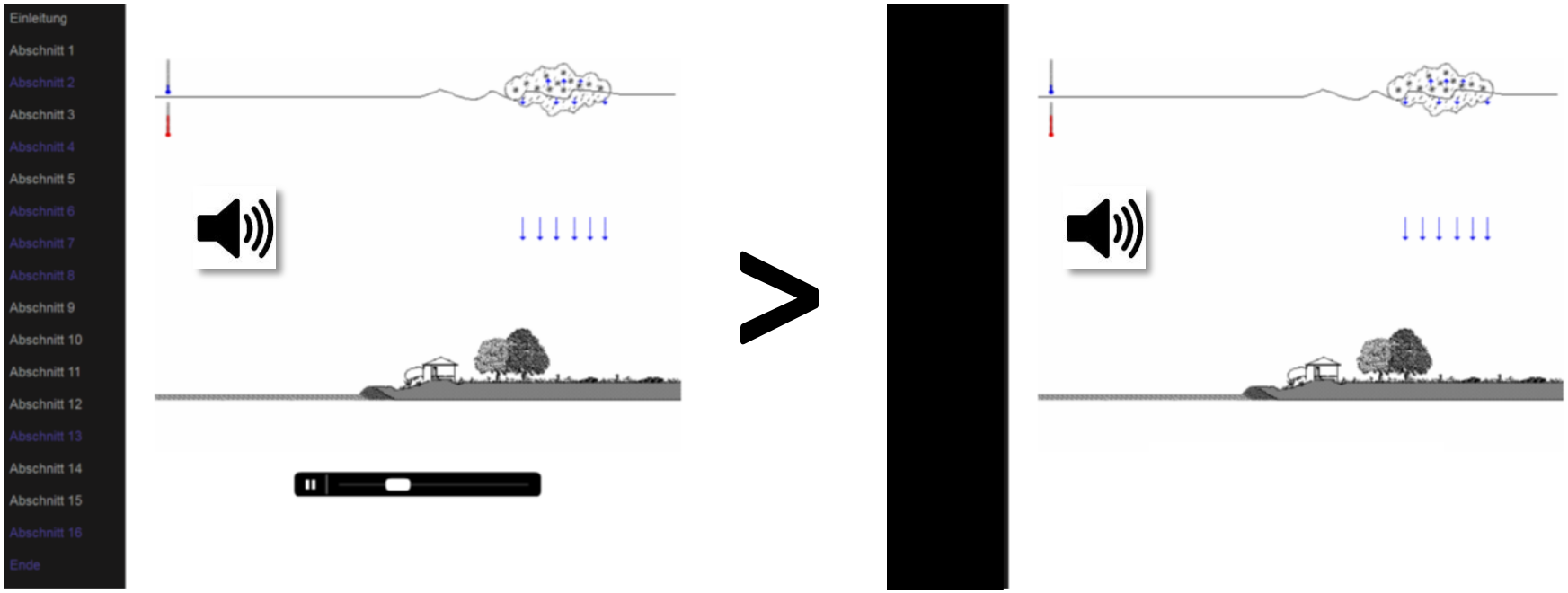
- other "Design Principle" (e.g., learner control/segmenting)

- manipulation for ego depletion (6 min.) not intense enough for learning?
  → "boosting" manipulation for ego depletion

Segmenting Principle

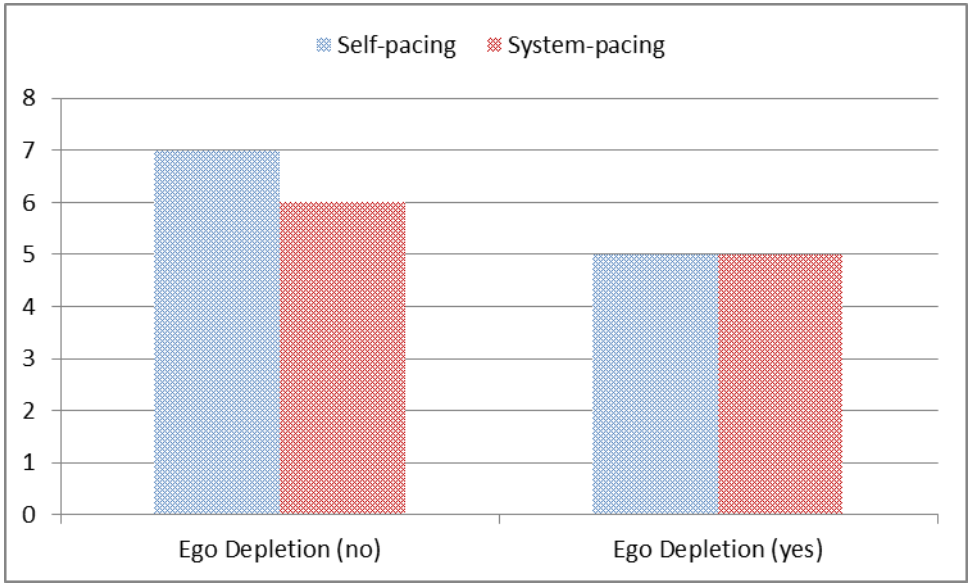
Segmenting (Mayer, 2009, 2014; Scheiter, 2014)

- better learning outcomes when learning with segmented content in a self-paced manner
  (reduction of ECL; germane resources can be invested)



Hypotheses & Research Questions

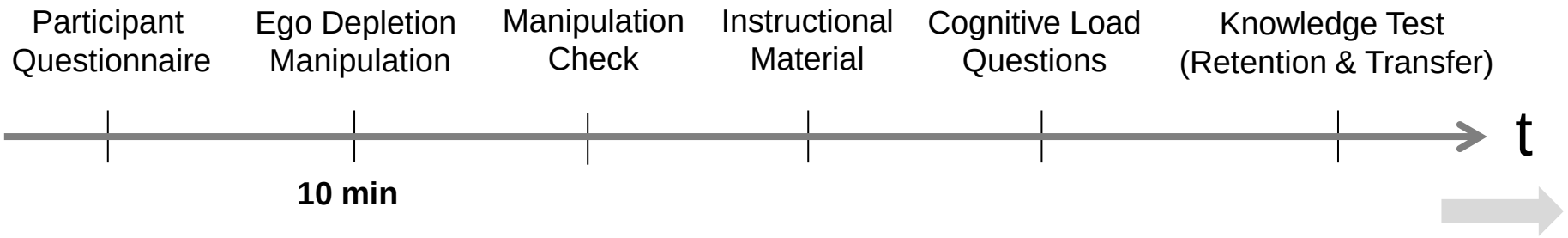
1) Learning under Ego Depletion leads to poorer performance
2) Interaction of Learning Condition & Ego Depletion
   - nondepleted: self-pacing > system-pacing
   - Ego Depletion: self-pacing =< system-pacing



2x2-Design

N=100 participants (55 female; 44 male; age: *M* = 22.56, *SD* = 3.20)

Instructional Material	Ego Depletion: Yes	Ego Depletion: No
Self-paced	n=25	n=25
System-paced	n=25	n=25



Ego Depletion Manipulation

Writing task (Bertrams, Englert, Dickhäuser, & Baumeister, 2013):
Transcribing a text on a blank sheet (**10 min**.)

Manipulation:

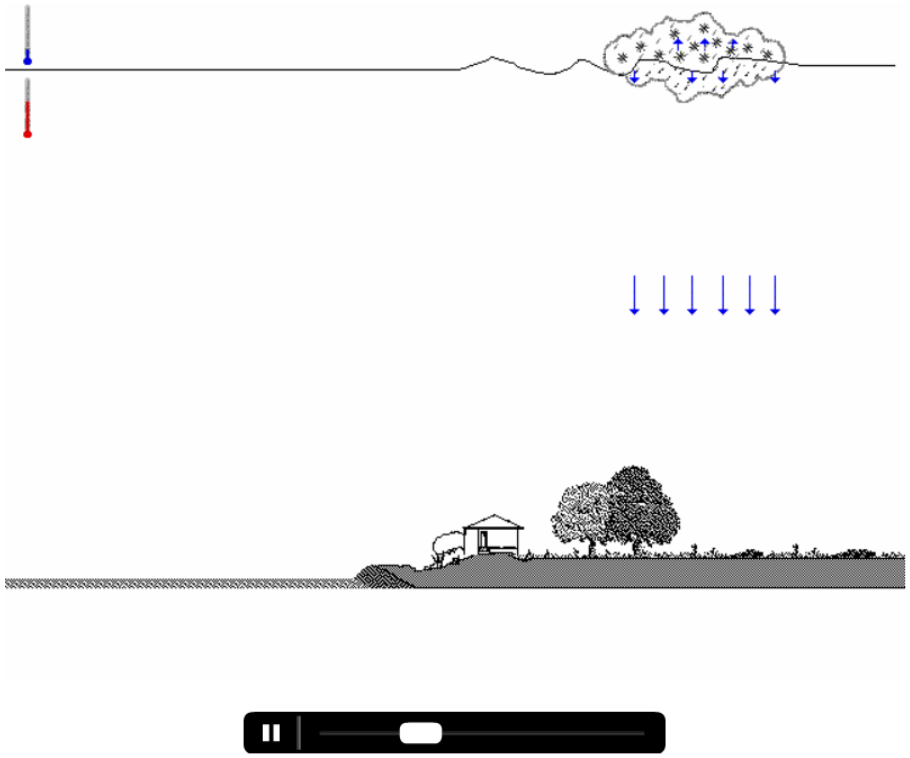
- No Ego Depletion: usual transcription
- Ego Depletion: omit the letters e and *n* wherever they would normally appear in the transcription:
  e.g.: *participats i th dpltio coditio wr istructd to omit th lttrs **e** ad **n***

- Manipulation Check: 3 items asking for Exhaustion, Difficulty and Suppression (of usual writing behavior)
  → "Depletion-Score"

Instructional Material: System-pacing

„How lightning works“: 16 narrated slides (cf. Mayer, 2001, 2005, 2009, 2014,…)

Instructional Material: Self-pacing



Self-pacing:

- **Play/Pause-Button & Slider for Narration**
- **Hyperlinks on the left; no „Next“- or „Back“-Button → not necessary linear order**

(cf. Kühl, Eitel, Damnik, & Körndle, 2014; Tabbers & de Koeijer, 2010)

Subjective Ratings of Cognitive Load

Scales from 1 to 7

Mental Effort:

- *„How much effort did you invest in order to understand the content?“* (Paas, 1992)

Difficulty:

- *„How difficult was it for you to learn with the material?”*

Knowledge Tests

Retention (1 question; cf. Moreno & Mayer, 1999):

- *"Describe how lightning works..."*

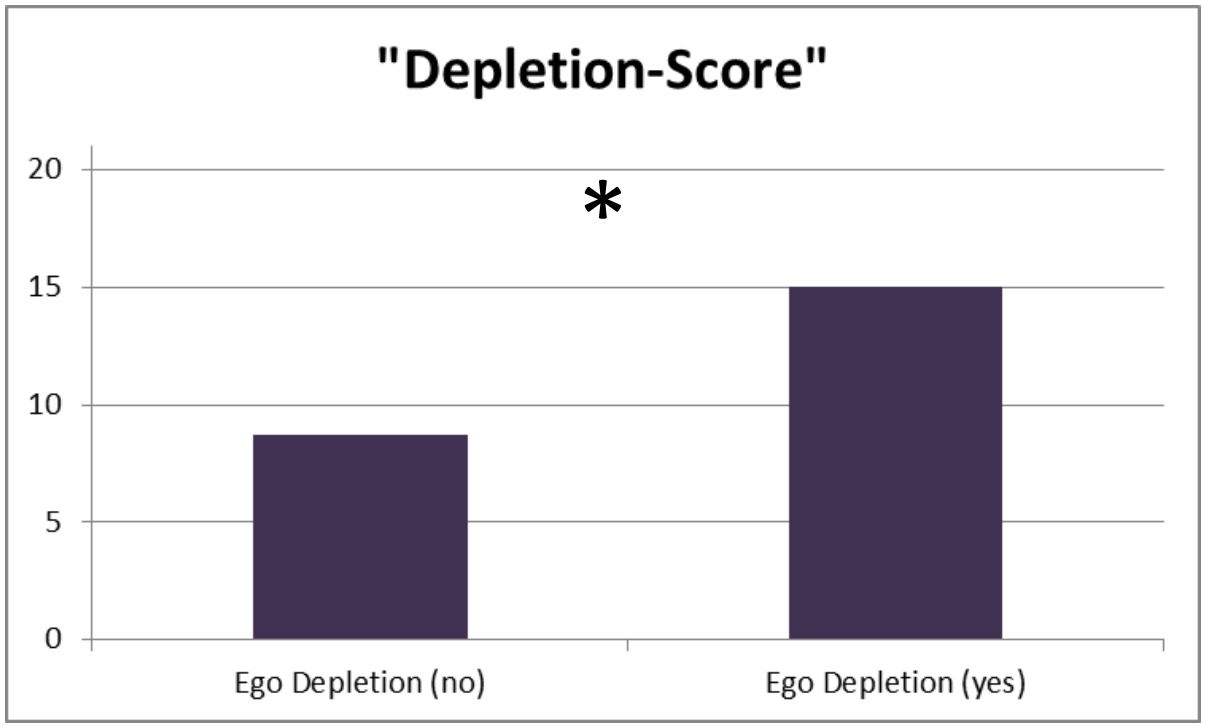
Transfer (4 questions; cf. Moreno & Mayer, 1999):

- *E.g., "How could the intensity of lightning be decreased?"*

Results – Manipulation Check

Manipulation-Check Ego Depletion

$t(95.56) = 11.59$, $p < .001$

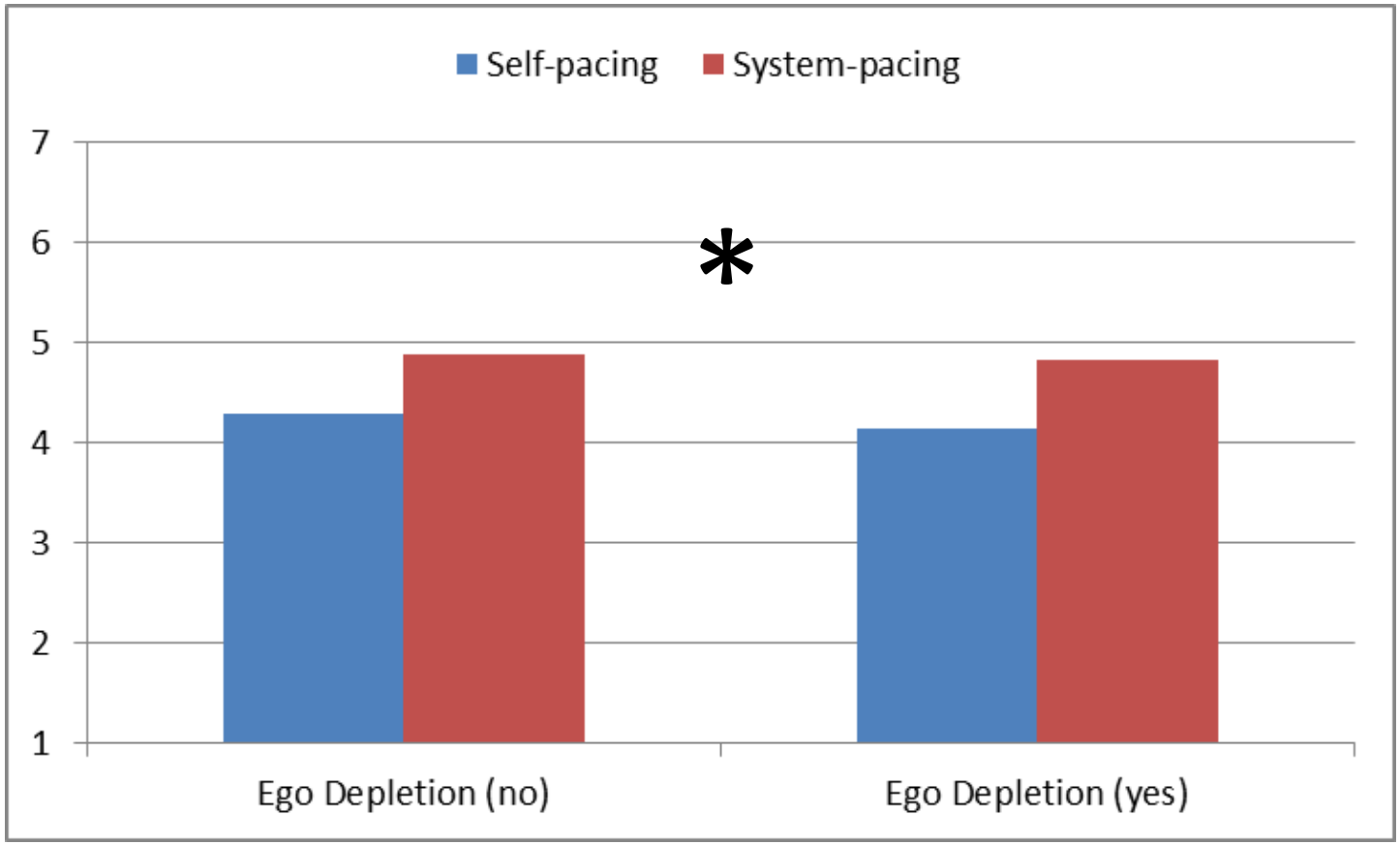


Results – CL: Effort

Main effect EgoDep:
$F(1, 96) = 1.14$,
$p = .28$, $\eta^2_p = .012$

Main effect Pacing:
$F(1, 96) = 5.17$,
$p = .03$, $\eta^2_p = .051$

Interaction EgoDep x Pacing:
$F < 1$, *ns*

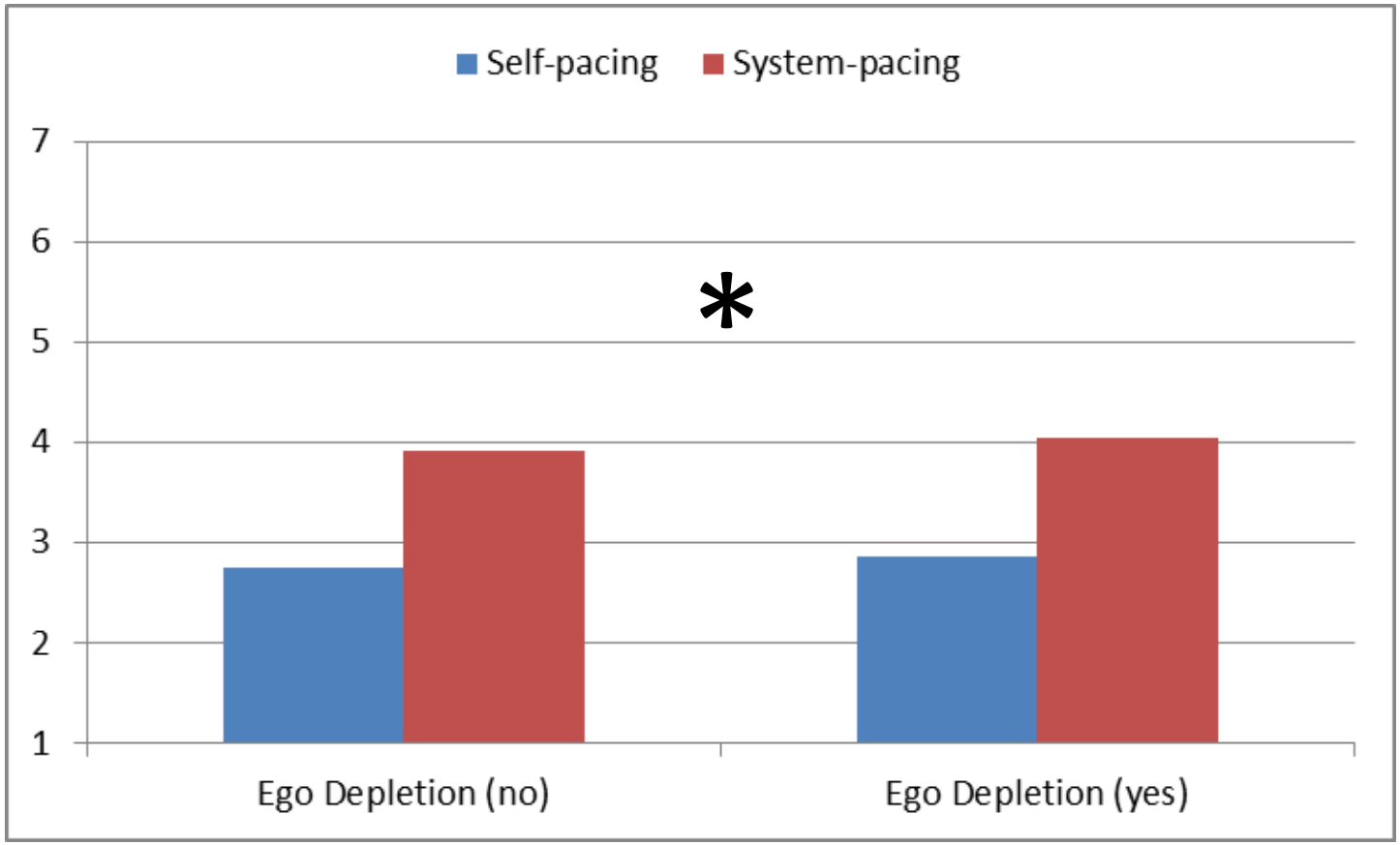


Results – CL: Difficulty

Main effect EgoDep:
F < 1, *ns*

Main effect Pacing:
$F(1, 96) = 19.15$,
$p < .001$, $\eta^2_p = .166$

Interaction EgoDep x Pacing:
F < 1, *ns*

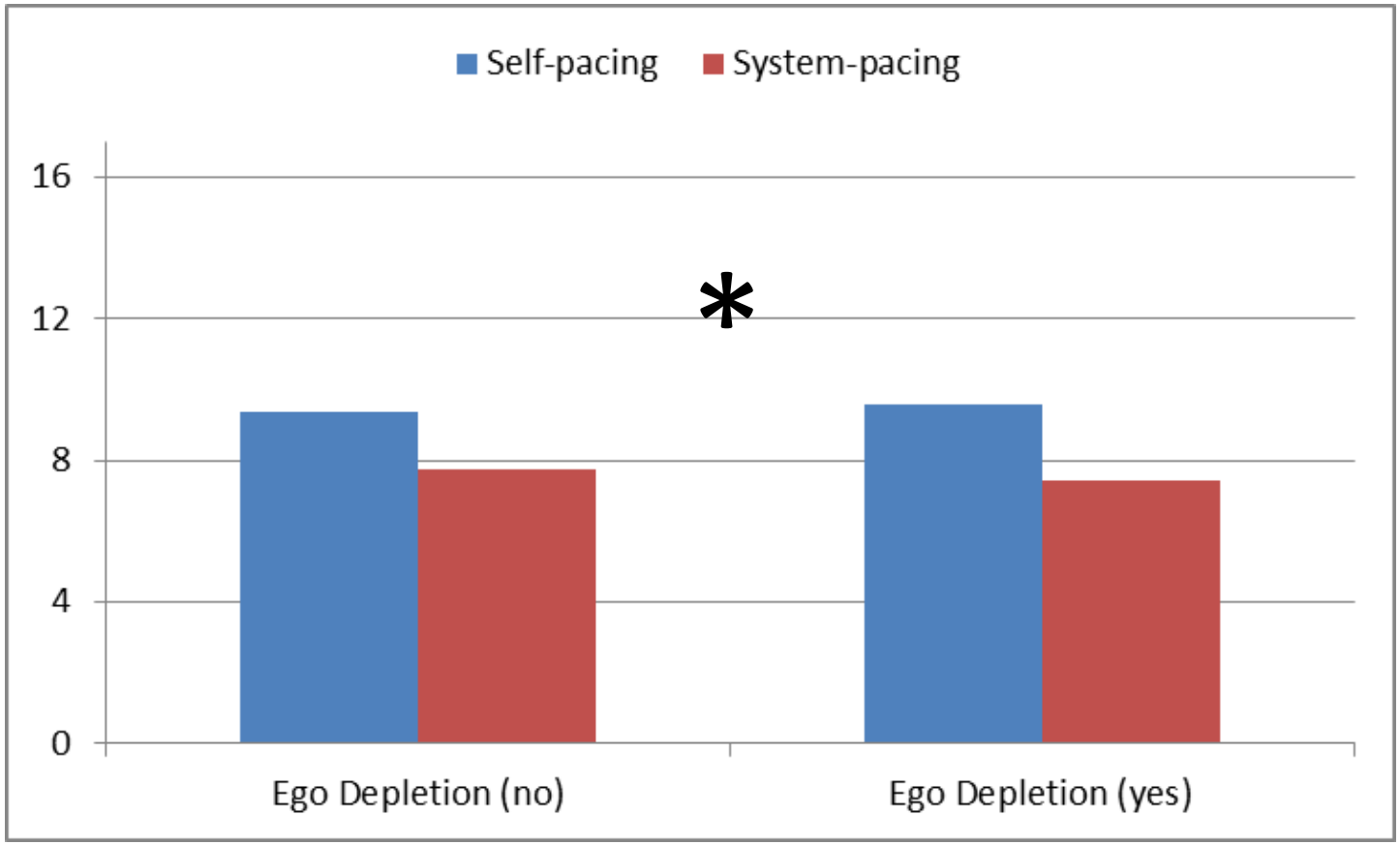


Results – Retention

Main effect EgoDep:
F < 1, *ns*

Main effect Pacing:
$F(1, 96) = 7.28$,
$p < .01$, $\eta^2_p = .070$

Interaction EgoDep x Pacing:
F < 1, *ns*



Results – Transfer

Main effect EgoDep:
F < 1, *ns*

Main effect Pacing:
F < 1, *ns*

Interaction EgoDep x Pacing:
F < 1, *ns*

Summary of Results

- Manipulation-Check: higher Depletion-Score
- Ego Depletion (vs. no Ego Depletion)
  - no influence on perceived difficulty or mental effort
  - no influence on learning outcomes
- Self-pacing (vs. system-pacing)
  - less invested mental effort and less perceived difficulty under self-pacing
  - better Retention, but no impact on Transfer

Discussion

Ego Depletion and CLT:

- no influence of Ego Depletion on learning and Cognitive Load (2 Experiments)
  → impact on cognitive processes overestimated?
- recent meta-analysis is questioning the effect of Ego Depletion and the idea of one limited resource…
  (Carter, Kofler, Forster, & McCullough, 2015)
- What about related concepts such as cognitive fatigue (e.g., Ackerman, 2011)?

Thank you for your attention!!!