Powerful Instructions: Automaticity without Practice

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Meiran was supported, together with Todd, S. Braver, by a USA-Israel Binational Science Foundation Grant #2011/246. De Houwer and Liefooghe were supported by Methusalem Grant BOF16/MET_V/002 of Ghent University and an Interuniversity Attraction Poles grant of the Belgian Science Policy Office (P7/33).

Abstract

Automaticity is widely assumed to reflect hard-wired tendencies or the outcome of prior practice. Recent research on *automatic effects of instructions* (AEI), however, indicates that newly instructed tasks can become immediately automatic without ever been practiced. This research shows that the representations underlying AEI need not always be directly linked to an overt response, must be highly accessible for future use, and involve bi-directional links between stimuli and responses. AEI was also found to reduce with increasing intellectual abilities among young adults and from childhood to young adulthood, possibly due to improved abstract cognitive control. We argue that AEI effects are based on the unintentional retrieval of episodic memories that encode instructions.

Powerful Instructions: Automaticity without Practice

We often behave and think automatically, that is, quickly and effortlessly, without the intention to think or behave in that way. Automaticity liberates attention (e.g., allows one to engage in a conversation with a passenger while driving) and frees us from the need to make online choices by relying on choices made beforehand. Research suggests that processes can be automatic in different ways (Bargh, 1992; Logan, 1985; Moors & De Houwer, 2006), leading some researchers to abandon an "all-or-none" view of automaticity (Bargh, 1992; Moors & De Houwer, 2006). From this perspective, it only makes sense to regard processes as automatic with reference to specific features (e.g., automatic in the sense of unintentional). Despite this change in perspective, there remains a prevalent assumption that automatic behavior reflects either hard-wired processes (e.g., when gazing towards an abrupt stimulus onset) or over-training (e.g., when reading words; Logan, 1985). In this paper, we review recent research on *automatic effects of instructions* (AEI), a phenomenon that challenges this prevalent assumption by showing evidence for unintentional activation of completely new tasks that had just been instructed and are neither hard-wired, nor practiced. This research continues previous efforts beginning already in the first half of the 20th century (Hommel, 2000, for review).

The relevance of AEI extends beyond automaticity because it highlights an important consequence of the evolution of communication and language that characterize our species. Specifically, AEI shows the potency of instructions (of immediately causing automaticity) when instructions are exchanged on the fly, improving teamwork efficiency, as required by our ancestors when hunting in teams, for example. The modern counterparts of these tasks include police chases and moving large pieces of furniture up the stairway. Additionally, this research may change our views of intentionality and moral responsibility, showing that (in some cases), when the intention to carry out an act is made ahead of the act, the online involvement of intentional control may be reduced. Finally, AEI may be viewed as the short-term counterpart of prospective memory tasks, where pending intentions have been shown to unintentionally activate related contents (Goschke & Kuhl, 1993), and where concrete if-then action plans, or “implementation intentions” were shown to boost performance (Gollwitzer, 1999). Yet, prospective memory tasks regard actions that may have been performed beforehand and are to be performed in the relatively distant future (e.g., remember taking the pill tonight), whereas AEI-tasks are novel and regard the near-immediate future (e.g., warning a teammate regarding an unexpected obstacle).

Recently Introduced Techniques to Study AEI

Prior research (e.g., Cohen-Kdoshay & Meiran, 2007; De Houwer, Beckers, Vandorpe, & Custers, 2005; Wenke, Gaschler, & Nattkemper, 2007) revealed phenomena that are somewhat inconclusive with respect to whether they represent AEI (Meiran, Pereg, Kessler, Cole, & Braver, 2015b), making it important to ask what criteria should a successful demonstration of AEI meet? We suggest that AEI must be observed in novel action-related instructions that have not yet been executed overtly (to rule out the involvement of prior practice), and should indicate *unintentional* execution (to meet this criterion for automaticity). Below we review two relatively recent lines of research with two different paradigms, both yielding evidence for AEI that meets these requirements. Both paradigms have in common an experimental design involving many different novel tasks, each instructed and then (typically) executed once or twice, before moving to the next task.

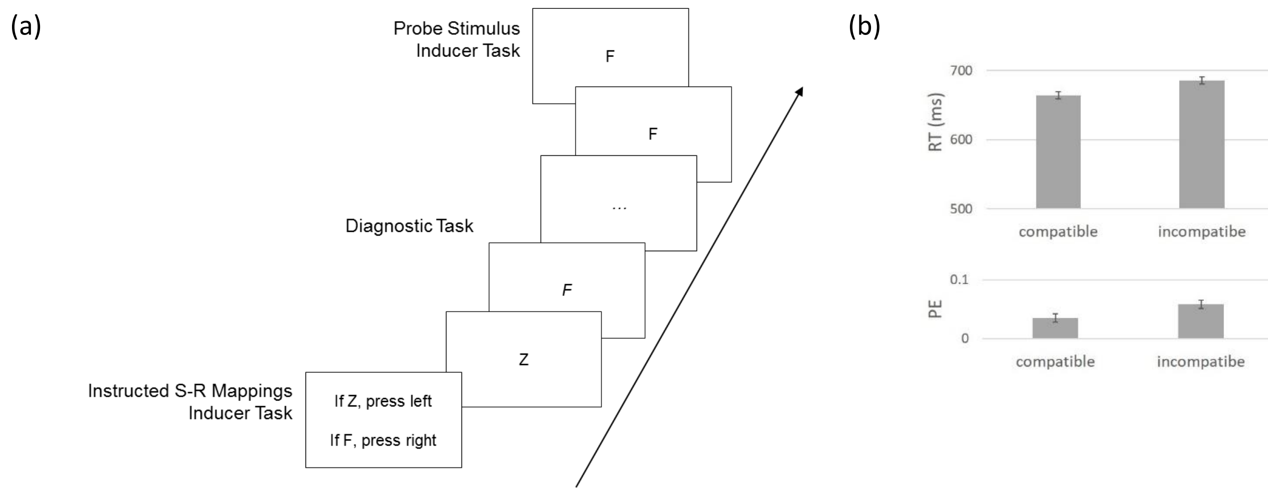
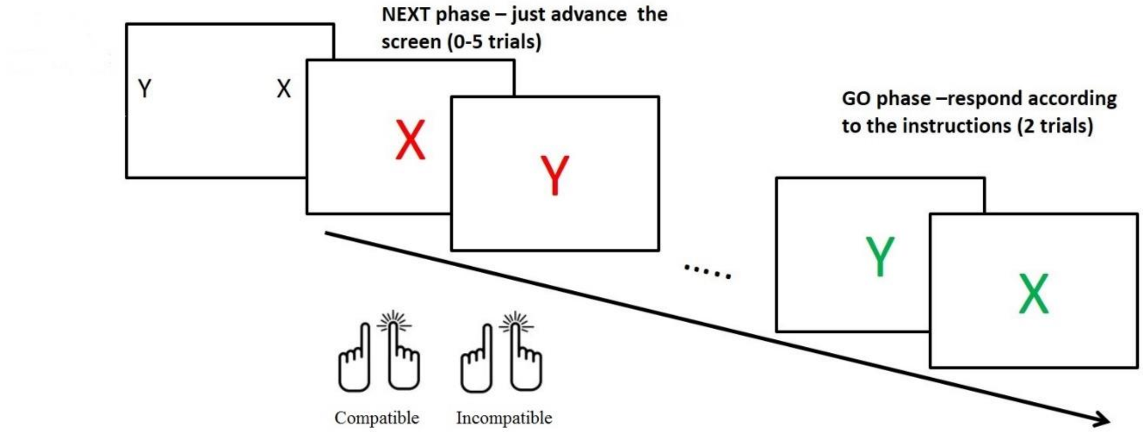


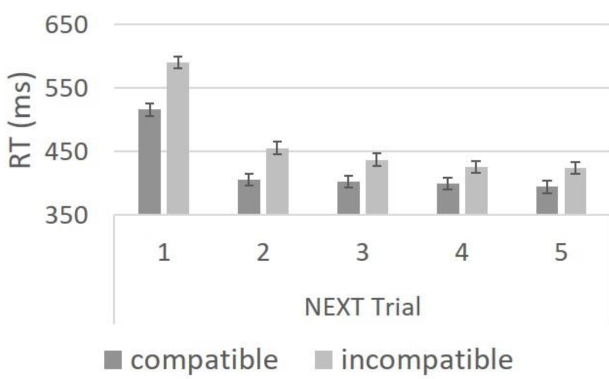
Figure 1.(a) The inducer-diagnostic (ID) procedure (Liefooghe et al., 2012). Each run involved new stimulus-response instructions (those in the figure are just one example) followed by a variable number of diagnostic (font decision) trials, and ending with a single inducer probe trial in which the new instructions were implemented for the first and only time. (b) Diagnostic-task results (N=166, RT=reaction-time, PE=proportion of errors) indicate poorer font decision performance when the response was incompatible with the instructed task, showing that the newly instructed task rules were retrieved unintentionally.

The *Inducer-Diagnostic (ID) design* was introduced by Liefooghe, Wenke, and De Houwer (2012, Figure 1a), who presented participants with different runs of trials. On each run, two tasks had to be performed: the *inducer* task and the *diagnostic* task. Both tasks shared the same stimuli and responses, but employed a different decision rule. At the start of each run, two new arbitrary stimulus-response rules of the inducer task were presented (e.g., ‘X’→left; ‘Y’→ right). After the instructions, there were several diagnostic trials in which participants made font decisions (e.g., upright→left; *italic*→ right). During the last phase of the run, the inducer task was implemented for the first (and only) time.

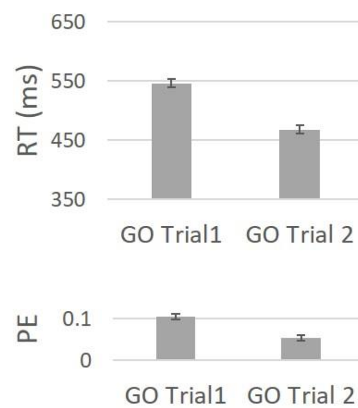
Liefooghe et al. (2012) observed that performance in the diagnostic (font decision) task was impaired when the correct response mismatched with the inducer instructions (e.g., ‘X’ presented in italics, Figure 1b), indicating an “instruction-based congruency effect”. The fact that the diagnostic task was performed prior to the first overt execution of the inducer instructions supports the conclusion that the aforementioned effect reflects AEI.

(a)





(b)



(c)

Figure 2. (a) The NEXT paradigm (Meiran et al., 2015) involved instructions regarding the GO phase ("X" and "Y" are just one example), a NEXT phase involving advancing to the next screen by pressing a fixed key (0-5 trials) and instruction application (GO phase, 2 trials). NEXT responses were either compatible (e.g., "X") or incompatible (e.g.,"Y") with the instructed GO phase response. (b) NEXT results (RT as a function of NEXT Trial Number, N) showing slower screen advancement responses to stimuli whose instructed response mismatched the NEXT response, and (c) GO results, showing better first than second GO response (N=167; RT=reaction-time, PE=Proportion of errors).

The *NEXT task* was introduced by Meiran et al. (2015b), Figure 2a). Like the ID, NEXT involved runs ("miniblocks"), each beginning with stimulus-response instructions of a new inducer (GO) task, with unique stimuli mapped to key presses, and a very simple diagnostic (NEXT) task that required advancing to the next screen with a fixed response. A core finding is the NEXT effect (an AEI marker): slower NEXT responses in incompatible trials. The NEXT paradigm thus involves a simpler diagnostic task than the ID. Furthermore, this diagnostic task is not described as a task at all, and thus does not involve any choice (beyond the choice to advance to the next screen and not to execute the GO task). Furthermore, unlike the studies using the ID paradigm that had so far reported results pooled across all the diagnostic trials, reports from studies using the NEXT paradigm examined the influence of the sequential positioning of the NEXT trial (Figure 2b) and GO trial (Figure 2c). This made it possible to examine AEI already in the first NEXT trial coming immediately after the instructions. The presence of AEI in the first NEXT trial thus enabled ruling out the possible involvement of prior (covert) practice that could take place in the course of the diagnostic task.

Importantly, the NEXT effect was numerically largest in the first NEXT trial in all the experiments run so far (see Figure 2b, showing NEXT reaction times according to Compatibility and the sequential position of the NEXT trial within the miniblock, N). This finding implies that the congruence effect observed in the ID paradigm (Liefooghe et al., 2012) is (a) probably an underestimation given that it includes all NEXT trials, and (b) provides a trustworthy index of AEI because it is unlikely to reflect automaticity that was built up as a result of prior practice. An additional finding in the NEXT paradigm is the GO-Trial effect indicating a relatively slow and inaccurate first response compared to second GO response.

What have we Learned about AEI?

Results from studies using the two paradigms show that AEI depends to some degree on having an intention to successfully execute the instructed plan. For example, Liefooghe et al. (2012) showed that AEI is reduced to non-significant levels when participants were required to memorize the instructions for later recognition instead of actual execution. Along a similar line, Liefooghe, De Houwer, and Wenke (2013) demonstrated that AEI depends on the degree by which participants actively prepare for the inducer task. Similarly, the NEXT effect was sustained throughout the NEXT phase only when participants were strongly encouraged to maintain high readiness to execute the instructions (very little opportunity, 2 trials, was given to demonstrate success), while the NEXT effect faded quickly during the NEXT phase when readiness was less strongly emphasized (10 GO trials, allowing participants not to prepare and use practice; Meiran et al., 2015).

Does AEI reflect an unintended activation of a motor plan? Meiran et al. (2015) showed that the NEXT effect is primarily due to slowing in incompatible NEXT trials (as compared to neutral NEXT trials involving stimuli that were not been linked to any response). This incompatibility-related slowing shows unintentional retrieval of the competing response (e.g., the left key in Figure 2a). More directly, Everaert, Theeuwes, Liefooghe, and De Houwer (2014) observed that the brain lateralized readiness potential (reflecting activation of the motor plan) deflected in the direction of the response tendency that corresponded with the instructed SR mappings of the inducer task. Meiran, Pereg, Kessler, Cole and Braver (2015a) took this finding one step further by requiring participants to withhold responding altogether during the NEXT phase. Their rationale was that, when there is a diagnostic task, reflexivity is not full-blown because a critical component, *action initiation,* is actually intended because it is involved in the diagnostic task. Lateralized readiness potential results show that stimuli presented in the NEXT phase activated the motor cortex that corresponded to the instructed response. Aside from providing a conceptual replication of Everaert et al., the results provide evidence that newly instructed rules can also be *initiated* reflexively.

Studies suggest that, unlike practice-based automaticity, AEI reflects rather abstract codes in that they are found also when the inducer and the diagnostic task overlap only at the conceptual level (e.g., pressing left vs. saying 'left', Liefooghe et al., 2012, and object names vs. pictures, Tibboel, Liefooghe, & Houwer, 2016). In another study, Theeuwes, Eder, De Houwer, and Liefooghe (2015) examined the direction of the effects of instructions. Specifically, they presented new Response-Effect (RE) contingencies at the start of each run (e.g., "if you press the left key, the letter Q will appear on the screen", i.e., left→Q, and similarly right→P). These contingencies were probed at the end of each run (i.e., inducer task) by having participants add a missing letter (e.g., 'P') to a display by pressing e.g., the right key. Results showed significant RE congruency effects (quicker font decisions to stimuli that were expected to be produced by a given response according to the instructions), suggesting that the RE instructions allowed for backward activation of responses by the effect stimuli (e.g., Q, R). Braem, Liefooghe, De Houwer, Brass, and Abrahamse (2017) showed that instructions have automatic effects even when the diagnostic task is presented in a different context (screen location) than the instructions and the inducer task. Last, AEI can involve abstract rules and not be restricted to stimulus-response rules. Specifically, Meiran and Pereg (2017) instructed participants which one of two familiar tasks to execute by means of a newly instructed task-cue (e.g., the picture of a piano cued an up-vs.-down judgement of stimulus location) that changed between miniblocks. Hence, the instructions in this case linked a newly introduced stimulus and a familiar task. Results show that when this task-cue (e.g., the piano picture) was presented in a tailored diagnostic task where its identity was irrelevant, it nonetheless retrieved of the associated task.

AEI shows surprising individual differences and developmental trends. Meiran, Pereg, Givon, Danieli, and Shahar (2016) found that, predictably, participants high in procedural working memory, mental speed and fluid intelligence were better prepared to execute the GO phase. Surprisingly, participants with better mental speed and better GO task preparedness had relatively *small* NEXT compatibility effects. Using a child-adapted version of the NEXT paradigm, Verbruggen, McLaren, Pereg, & Meiran (2016) found that the difference between younger (4-11 yo) and older (17-19 yo) kids resembles the aforementioned differences between high ability and low-ability young adults. Possibly, these findings relate to the ability to represent the task hierarchically, enabling action deferral until certain branching conditions are met (here, the initiation of the inducer task, Cole, Meiran, & Braver, in press, see also Koechlin, Ody, & Kouneiher, 2003).

Conclusions

There can now be little doubt that AEI exist. We also learned that the representations underlying AEI need not always be directly linked to an overt response, must be highly accessible for future use, and involve bi-directional links between stimuli and responses. Furthermore, we discovered that AEI reduces from childhood to young adulthood and with increasing ability among young adults.

If automatic effects do not necessarily depend on hard-wired or over-trained processes, what other processes might produce them? One possibility is the automatic retrieval of episodic representations from memory (e.g., Hintzman, 1988; Logan, 1988; Schmidt, De Houwer, & Rothermund, 2016). For instance, when instructed 'X'→left, an episodic trace of this event might be stored in memory. When the letter 'X' is presented later, the episodic trace is automatically retrieved, resulting in a bias to press left. The suggestion is compatible with recent findings (Pfeuffer, Moutsopoulou, Pfister, Waszak, & Kiesel, 2017) that merely watching the SR association without needing to execute it may cause a form of AEI. For representations supporting AEI, it may thus be sufficient that participants attend to certain aspects of the information. This conclusion further implies that, contrary to the popular dichotomy between control and automaticity, attentional control may enable automatic processing, in line with Moors's (2016) recent theory of automaticity.

Many questions remain unanswered such as what is the relationship between skill-based automaticity and AEI (Braem et al., 2017) and what are the relative constraints, advantages and disadvantages of each form of automaticity? Recent research on the neural basis of rapid learning from instructions (Cole, Laurent, & Stocco, 2013) should also be extended to explain AEI (Brass, Liefooghe, Braem, & De Houwer, in press; Cole, et al., in press).

In sum, research on AEI challenges the widespread conception of automaticity as requiring hard-wired or over-trained processes. It is, however, in line with models emphasizing the role of episodic memory retrieval.

References

Bargh, J. A. (1992). The ecology of automaticity: Toward establishing the conditions needed to produce automatic processing effects. *The American Journal of Psychology*, *105*, 181–199. https://doi.org/10.2307/1423027

Brass, M., Liefooghe, B., Braem, S., & De Houwer, J. (in press). Following new task instructions: Evidence for a dissociation between knowing and doing. *Neuroscience & Biobehavioral Reviews*.

Braem, S., Liefooghe, B., De Houwer, J., Brass, M., & Abrahamse, E. L. (2017). There are limits to the effects of task instructions: Making the automatic effects of task instructions context-specific takes practice. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*, 394–403. https://doi.org/10.1037/xlm0000310

Cohen-Kdoshay, O., & Meiran, N. (2007). The representation of instructions in working memory leads to autonomous response activation: Evidence from the first trials in the flanker paradigm. *The Quarterly Journal of Experimental Psychology*, *60*, 1140–1154. https://doi.org/10.1080/17470210600896674

Cole, M. W., Laurent, P., & Stocco, A. (2013). Rapid instructed task learning: A new window into the human brain's unique capacity for flexible cognitive control. *Cognitive, Affective, & Behavioral Neuroscience*, *13*, 1–22. https://doi.org/10.3758/s13415-012-0125-7

Cole, M. W., Braver, T. S. & Meiran, N. (in press). The task novelty paradox: Flexible control of inflexible neural pathways during rapid instructed task learning. *Neuroscience and Biobehavioral Reviews.*

De Houwer, J., Beckers, T., Vandorpe, S., & Custers, R. (2005). Further evidence for the role of mode-independent short-term associations in spatial Simon effects. *Perception & Psychophysics*, *67*, 659–666. https://doi.org/10.3758/BF03193522

Everaert, T., Theeuwes, M., Liefooghe, B., & Houwer, J. D. (2014). Automatic motor activation by mere instruction. *Cognitive, Affective, & Behavioral Neuroscience*, *14*, 1300–1309. https://doi.org/10.3758/s13415-014-0294-7

Gollwitzer, P. M. (1999). Implementation intentions: strong effects of simple plans. *American Psychologist*, *54*, 493.

Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 1211–1226. https://doi.org/10.1037/0278-7393.19.5.1211

Hintzman, D. L. (1988). Judgments of frequency and recognition memory in a multiple-trace memory model. *Psychological Review*, *95*, 528–551. https://doi.org/10.1037/0033-295X.95.4.528

Hommel, B. (2000). The prepared reflex: Automaticity and control in stimulus-response translation. In S. Mosell & J. Driver (Eds.), *Contol of cognitive processes: Attention & Performance XVIII* (pp. 247–273).

Koechlin, E., Ody, C., & Kouneiher, F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science*, *302*(5648), 1181–1185. https://doi.org/10.1126/science.1088545

Liefooghe, B., Houwer, J., & Wenke, D. (2013). Instruction-based response activation depends on task preparation. *Psychonomic Bulletin & Review*, 20, 481–487. https://doi.org/10.3758/s13423-013-0374-7

Liefooghe, B., Wenke, D., & De Houwer, J. (2012). Instruction-based task-rule congruency effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*, 1325–1335. https://doi.org/10.1037/a0028148

Logan, G. D. (1985). Skill and automaticity: Relations, implications, and future directions. *Canadian Journal of Psychology, 39*, 367–386.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review*, *95*, 492–527. https://doi.org/10.1037/0033-295X.95.4.492

Meiran, N., & Pereg, M. (2017). Automatic retrieval of newly instructed cue-task associations seen in task-conflict effects in the first trial after cue-task instructions. *Experimental Psychology*, *64*, 37–48. https://doi.org/10.1027/1618-3169/a000349

Meiran, N., Pereg, M., Givon, E., Danieli, G., & Shahar, N. (2016). The role of working memory in rapid instructed task learning and intention-based reflexivity: An individual differences examination. *Neuropsychologia*, *90*, 180–189. https://doi.org/10.1016/j.neuropsychologia.2016.06.037

Meiran, N., Pereg, M., Kessler, Y., Cole, M. W., & Braver, T. S. (2015a). Reflexive activation of newly instructed stimulus–response rules: Evidence from lateralized readiness potentials in no-go trials. *Cognitive, Affective, & Behavioral Neuroscience*, *15*, 365–373. https://doi.org/10.3758/s13415-014-0321-8

Meiran, N., Pereg, M., Kessler, Y., Cole, M. W., & Braver, T. S. (2015b). The power of instructions: Proactive configuration of stimulus–response translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*, 768–786. https://doi.org/10.1037/xlm0000063

Moors, A. (2016). Automaticity: Componential, causal, and mechanistic explanations. *Annual Review of Psychology*, *67*, 263–287. https://doi.org/10.1146/annurev-psych-122414-033550

Moors, A., & De Houwer, J. (2006). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin*, *132*, 297–326. https://doi.org/10.1037/0033-2909.132.2.297

Pfeuffer, C. U., Moutsopoulou, K., Pfister, R., Waszak, F., & Kiesel, A. (2017). The power of words: On item-specific stimulus–response associations formed in the absence of action. *Journal of Experimental Psychology: Human Perception and Performance*, *43*, 328–347. https://doi.org/10.1037/xhp0000317

Schmidt, J. R., De Houwer, J., & Rothermund, K. (2016). The Parallel Episodic Processing (PEP) model 2.0: A single computational model of stimulus-response binding, contingency learning, power curves, and mixing costs. *Cognitive Psychology*, *91*, 82–108. https://doi.org/10.1016/j.cogpsych.2016.10.004

Theeuwes, M., De Houwer, J., Eder, A., & Liefooghe, B. (2015). Congruency effects on the basis of instructed response-effect contingencies. *Acta Psychologica*, *158*, 43–50. https://doi.org/10.1016/j.actpsy.2015.04.002

Tibboel, H., Liefooghe, B., & Houwer, J. D. (2016). Attention to future actions: The influence of instructed S-R versus S-S mappings on attentional control. *Psychological Research*, *80*, 905–911. https://doi.org/10.1007/s00426-015-0695-4

Verbruggen, McLaren, R., Pereg, M., & Meiran, N. (2016). *The development of proactive control and intention- based reflexivity: A cross-sectional study*. Presented at the The Annual Meeting of the Psychonomic Society, Boston MA, USA.

Wenke, D., Gaschler, R., & Nattkemper, D. (2007). Instruction-induced feature binding. *Psychological Research*, *71*, 92–106. https://doi.org/10.1007/s00426-005-0038-y