How are automatic processes elicited by intended actions?

Dana Ganor-Stem*1, Joseph Tzelgov2 and Nachshon Meiran2

1 Department of Psychology, Achva Academic College, MP . Shikmim, Israel
2 Department of Psychology, Ben-Gurion University of the Negev, Beer-Sheva, Israel

*Correspondence: danaga@bgu.ac.il

Edited by:
Asher Cohen, Hebrew University of Jerusalem, Israel

Keywords: automaticity, interference paradigm, task-dependence, automatic and intended actions

Although unintentionality is one of the key elements common to most traditional definitions of automaticity (e.g., Posner and Snyder, 1975; Shiffrin and Schneider, 1977; Hasher and Zacks, 1979; Jacoby et al., 1993; Tzelgov, 1997; Moors and De Houwer, 2006), more recent approaches pointed out that many automatic processes are affected and even elicited by intended processes (e.g., Bargh, 1989, 1992). Furthermore, processes need very little AUP to occur, their dependence on AUP. Some automatic processes can be triggered by AUP, and in some cases they will not start without it. Automatic processes differ in the display reduces the Stroop effect, an effect referred to as the dilution effect (Kahneman and Chajczyk, 1983). On the other hand, narrowing visual attention to the letter level by coloring only a single letter in a color word causes a reduction in the Stroop effect (Besner et al., 1997).

AUP AT THE STIMULUS-IDENTITY LEVEL

The experimental task directs the participant’s attention to a specific stimulus, which may be associated with one or more processes. Strong AUP at the stimulus-identity level exists when the task directs the participant’s attention to a stimulus that is strongly associated with a particular highly practiced (yet, currently irrelevant) process. In such cases, attending to that stimulus might activate this process.

There is an especially strong association between words and the highly practiced skill of reading (Besner et al., 1997). As a consequence, attending to a word might activate the reading process and this should impair performance when the required task is not reading. Moreover, the activation of the reading process should increase with the resemblance of the stimulus to a word. Indeed, Monsell et al. (2001) showed that the slowing in a color naming task was dependent on the extent to which the non-words resembled words. Color naming was slower when the carrier stimulus resembled a word than when it did not. The difference between AUP at the stimulus location and at the stimulus identity level is similar to that between “where” and “what” in visual attention.

AUP AT THE PROCESS LEVEL

The experimental task indicates the nature of the process required. There are two types of AUP at the process level. First, the intention to perform a process might activate related processes. Second, the process...
required by a task might still be active even when it is no longer needed.

**AUP FROM THE PROCESS REQUIRED BY THE CURRENT TASK**

Experimental tasks require a wide variety of processes, such as naming, detection, classification, and comparison. The stronger the similarity or the association between the intended process and unintended ones is, the stronger the AUP. In this case, the process required by the task might activate related processes, perhaps through spreading activation.

Evidence for this type of AUP is provided, for example, by La Heij et al. (1998). Using the picture-word interference task, they found the gender congruency effect (difference in performance between trials in which the gender of the verbal title of the depicted object was congruent vs. incongruent with the gender of the word) only when participants produced noun phrases and not when they produced nouns only. Presumably the former activates gender-marking information to a greater extent than the latter does. Similar results were found in studies that looked at the effect of the grammatical category of the distractor word on performance in the same task (Pechmann and Zerbst, 2002; Pechmann et al., 2004). Analogous findings were reported by Vigliocco et al. (2005). Together, these studies suggest that the automatic activation of grammatical characteristics of an irrelevant stimulus during speech production depends on pre-activation of the specific grammatical information from the required task.

**AUP FROM THE PROCESS REQUIRED BY THE PREVIOUS TASK**

This type of AUP is strong when the unintended automatic process was required by the previous task. The processes required in a previous task, although not relevant anymore, might still be activated and influence the performance in the current task. The consistent pattern of poorer performance on task-switch trials (i.e., trials following a shift from one task to another) compared to task repetition trials is an example for such an effect (e.g., Kiesel et al., 2010; Meiran, 2010; Vandierendonck et al., 2010). It is partly due to carryover of activation from the previous task (e.g., Allport et al., 1994; Yeung et al., 2006).

**AUP AT THE STIMULUS-DIMENSION LEVEL**

The experimental task often requires a classification according to a certain dimension—size, color, polarity, etc. This might encourage the application of the same classification also to irrelevant stimuli. Strong AUP occurs when the dimension of interest is also applicable to other aspects or objects that are task-irrelevant (Kornblum et al., 1990; Kornblum and Lee, 1995).

Empirical evidence for this kind of AUP comes, for example, from the size congruency effect, which is found when a classification of digits according to physical size is required. Performance is enhanced when the numerical and physical sizes correspond, compared to when they do not, indicating the automatic processing of numerical magnitude (e.g., Henik and Tzelgov, 1982). In this case, the processing of the physical size required by the task might trigger the automatic processing of the irrelevant numerical size. Indeed, studies that used a luminance judgment found either no evidence for automatic numerical processing (Pinel et al., 2004) or a reduced effect (Rubinstei n and Henik, 2005; Cohen Kadosh and Henik, 2006).

In a similar manner, the Stroop effect varies as a function of the overlap at the stimulus-dimension level between the relevant ink-color and irrelevant word. It is largest for color words, decreases for color-associated words, and decreases even more for words unrelated to color (Klein, 1964; MacLeod, 1991; Sharma and McKenna, 1998; Risko et al., 2006).

The effect of AUP at the stimulus-dimension level is also found for involuntary attention shifts. Folk et al. (1992) showed that the occurrence of involuntary shifts of attention depended on task demands and specifically, on the relation between the properties of the cue and the properties required to locate the target. They were present when the cue shared a feature property that was critical to the performance of the target task; for example, when the target was defined by color, colored cues produced involuntary attention shifts. Note that this AUP level differs from the previous one because AUP at the stimulus dimension refers to the stimulus dimension that is task-relevant, while AUP at the process level refers to the mental operation that is employed. Different processes might be applied to the same dimensions.

**AUP AT THE RESPONSE LEVEL**

The task set specifies the response categories and the way they are mapped onto the actual responses. Strong AUP occurs when the processing of the irrelevant dimension can be mapped onto the same set of responses specified for the relevant dimension. Such overlap may enhance the indications for automaticity. Indeed, larger Stroop effects are found for words that are part of the set of possible responses than for words that are not (Klein, 1964; MacLeod, 1991; Sharma and McKenna, 1998).

The present work could be viewed as an extension of Kornblum’s dimensional overlap theory (Kornblum et al., 1990; Kornblum and Lee, 1995), which focused on stimulus-stimulus and stimulus-response overlap. We added to this framework the AUP at the stimulus location, stimulus identity, and process levels. Moreover, we related the systematic analysis of levels of AUP to degrees of automaticity. Automatic processes differ in the extent to which they depend on activation from the intended task, consistent with a gradual approach to automaticity (e.g., Moors and De Houwer, 2006). Some automatic processes need very little AUP to occur, with the least amount of AUP provided at the levels of stimulus location and stimulus identity. In fact, AUP at the stimulus level might be present even when there is no task at hand. In such cases, automatic processing will occur whenever the relevant stimulus is attended. In other cases, additional preconditions need to be met (e.g., Bargh, 1989, 1992). Such preconditions are provided by the other levels of AUP. The automatic process might occur only when the intended task involves a related process, a similar stimulus-dimension or the same response set.

**SUMMARY**

Although past works on automaticity acknowledged the fact that automatic processes are affected and even elicited by intended ones, there was no attempt to analyze this influence in detail. The present paper proposed a systematic analysis of
the ways the intended process activates or elicits the occurrence of the automatic one. Examples for the effects of the AUP levels on automatic processes in different domains demonstrate the generality of this analysis. Results from other paradigms such as the flanker and Simon tasks could nicely fit into this analysis, however they were omitted from this paper, due to space limitations. Note that the different AUP levels are not mutually exclusive and a certain task might produce multiple levels of AUP to the automatic process. This is the case of the color-word Stroop effect, where all levels of AUP operate, and this may account for the robustness of the effect.

AUP affects not only the presence of the automatic process but also its behavioral indicators. As described in this paper, numerous studies from different domains showed that stronger AUP processing led to stronger AUP-related behavioral indicators of automaticity compared to weak AUP.

ACKNOWLEDGMENTS

This research was supported by grants from the Israel Foundation Trustees and Israel Science Foundation (grant no. 906/12) to the first author.

REFERENCES

Alditt, A., Styles, E. A., and Hsieh, S. (1994). “Shifting intentional set: exploring the dynamic control of tasks,” in Attention and Performance XV: Conscious and Unconscious Processing, eds C. Umiltà and M. Moscovitch (Cambridge, MA: MIT Press), 421–452.

Bargh, J. (1992). “The ecology of automaticity: towards establishing the conditions needed to produce automatic processing effect. Am. J. Psychol. 105, 181–199. doi: 10.2307/1423027

Bargh, J. (1994). “The four horsemen of automaticity: awareness, intention, efficiency, and control in social cognition,” in Handbook of Social Cognition, eds R. S. J. Wyer and T. K. Srull (Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.), 1–40.

Bargh, J., Stolar, J., and Boutilier, C. (1997). The Stroop effect and the myth of automaticity. Psychon. Bull. Rev. 4, 221–225. doi: 10.3758/BF03209396

Bundesen, C. (1990). A theory of visual attention. Psychol. Rev. 97, 523–547. doi: 10.1037/0033-295X.97.4.523

Cohen Kadosh, R., and Henik, A. (2006). A common representation for semantic and physical properties: a cognitive-anatomical approach. Exp. Psychol. 53, 87–94. doi: 10.1076/1068-1634.53.2.87

Risko, E., Schmidt, J., and Besner, D. (2006). Filling a gap in the semantic gradient: color-associates and response set effects in the stroop task. Psychol. Bull. 13, 310–315. doi: 10.3758/BF03193849

Folk, C. L., Remington, R., and Johnston, J. C. (1992). Involuntary covert orientation is contingent on attentional control settings. J. Exp. Psychol. Hum. Percept. Perform. 18, 1030–1044. doi: 10.1037/0096-1523.18.4.1030

Hasher, L., and Zacks, R. T. (1979). Automatic and effortful processes in memory. J. Exp. Psychol. Gen. 108, 356–388. doi: 10.1037/0096-4458.108.3.356

Henik, A., and Tzelgov, J. (1982). Is three greater than two? a comparison of AUP to the automatic process. This is the case of the color-word Stroop effect, where all levels of AUP operate, and this may account for the robustness of the effect.

AUP affects not only the presence of the automatic process but also its behavioral indicators. As described in this paper, numerous studies from different domains showed that stronger AUP processing led to stronger AUP-related behavioral indicators of automaticity compared to weak AUP.
Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *J. Exp. Psychol.* 18, 643–662. doi: 10.1037/h0054651

Tzelgov, J. (1997). Specifying the relations between automaticity and consciousness: a theoretical note. *Conscious. Cogn.* 6, 441–451. doi: 10.1006/ccog.1997.0303

Tzelgov, J., and Ganor-Stern, D. (2005). “Automaticity in processing ordinal information,” in *Handbook of Mathematical Cognition*, ed J. I. D. Campbell (New York, NY: Psychology Press), 55–67.

Vandierendonck, A., Liefooghe, B., and Verbruggen, F. (2010). Task switching: interplay of reconfiguration and interference control. *Psychol. Bull.* 136, 601–626. doi: 10.1037/a0019791

Vigliocco, G., Vinson, D. P., and Siri, S. (2005). Semantic similarity and grammatical class in naming actions. *Cognition* 94, B91–B100. doi: 10.1016/j.cognition.2004.06.004

Yamaguchi, M., and Proctor, R. W. (2012). Multidimensional vector model of stimulus-response compatibility. *Psychol. Rev.* 119, 272–303. doi: 10.1037/a0026620

Yeung, N., Nystrom, L. E., Aronson, J. A., and Cohen, J. D. (2006). Between-task competition and cognitive control in task switching. *J. Neurosci.* 26, 1429–1438. doi: 10.1523/JNEUROSCI.3109-05.2006

Received: 18 July 2013; accepted: 25 October 2013; published online: 13 November 2013.

Citation: Ganor-Stern D, Tzelgov J and Meiran N (2013) How are automatic processes elicited by intended actions? *Front. Psychol.* 4:851. doi: 10.3389/fpsyg.2013.00851

This article was submitted to Cognition, a section of the journal Frontiers in Psychology.

Copyright © 2013 Ganor-Stern, Tzelgov and Meiran. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) or licensor are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.