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Automaticity

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Automaticity is a theoretical concept central to cognitive psychology and psycholinguistics, and more recently to social psychology. *Automaticity* has also been imported into theories of second language (L2) acquisition and L2 performance (DeKeyser, 2007a; Mitchell and Myles, 2004; Segalowitz, 2010) where it continues to be used widely. In its most general sense, *automaticity* has been used to refer to those properties of behavior that reflect the individual's ability to perform very rapidly and with little or no (conscious) effort. For example, a literate adult's recognition of letters of the alphabet in the first language (L1) is usually automatic in the sense of being extremely rapid and requiring little or no attention due to massive overlearning, whereas the ability to recognize letters drawn from a different alphabet in an L2 is usually not automatic, especially during the early phases of learning the language. Pashler (1998) suggests that the core propositions generally agreed upon in automaticity theories are the "lack of interference with competing tasks; functioning without voluntary control" (p. 358).

Several milestone contributions provide background for understanding how automaticity has been operationalized for research purposes in general and for L2 acquisition research in particular. Kahneman (1973) elaborated upon the idea that some behaviors can come to require little or no attention for their execution. Schneider and Shiffrin (1977) studied the effect of repetition on response times (RTs) in learning stimulus-response connections, by comparing the results of learning involving *consistent* mapping (when a given stimulus is always the target and never a non-target) with learning involving *varied* mapping (when a given stimulus is a target on some trials and a non-target on others). In tasks with massive practice over hundreds of trials involving consistent mapping, they found that responses became fast, relatively effortless and immune to interference from distracting stimuli – that is, processing had become automatic – in contrast to learning involving varied mapping. Schneider *et al.* (1984: 1) defined this automaticity as "a fast, parallel, fairly effortless process that is not limited by short-term memory (STM) capacity, is not under direct subject control, and is responsible for the performance of well-developed skill behaviors."

In short, the mental activities underlying a learned skill appear to take on new features as a result of massive practice – they are said to become more automatic. The process involved in this change is sometimes called *automatization*. Questions about automatization are relevant to learning in every skill domain, including L2 acquisition

where automatization is assumed to be important in fluency development (for implications of automaticity for L2 pedagogy see DeKeyser, 2001, 2007b; Johnson, 1996; Segalowitz, 2010; Skehan, 1998). It is important, therefore, for L2 researchers to find ways to distinguish automatic from non-automatic processing for measuring the automatization that results from learning and practice, and for studying the conditions leading to the development of automatic processing in L2 use.

While there is agreement on some of the general characteristics of automatic behaviors, consensus on how to operationally define automaticity for research purposes has proven elusive. The following ideas about what distinguishes automatic from non-automatic (sometimes called control) processes have motivated different researchers' operational definitions: automatic processing proceeds faster, it consumes little or no attentional resources (it is effortless), it reflects a change from a serial to a parallel mode of processing and it is ballistic (unstoppable once initiated and cannot be interrupted by other ongoing processes). As well, in the process of automatization, RTs improve over time in a pattern following a power law distribution. These properties of performance correspond to what many would normally expect *automatic processing* to refer to. However, the psychological literature also reveals that so-called automatic behaviors do not necessarily always exhibit all of the above features at the same time. Automaticity, therefore, is not a well-defined construct in the sense that there is no criterial feature or set of features that can be used to unambiguously distinguish all automatic from non-automatic behavior. This poses a problem for researchers wishing to investigate the acquisition of high-level skills in which automatic processing – in some sense of the word – plays a role. Pashler (1998: 357–89) provides a very useful discussion of the relevant issues here, one that challenges some widely held assumptions about automaticity. We turn now to discussion of automaticity in relation to L2 processing.

Automaticity and the L2

Some L2 theorists have used automaticity generically without proposing an operational definition or explicitly specifying what the contrasting non-automatic behavior might be. For example, Bybee (2008), in discussing fossilized features of L2 speech commented on how difficult it is to change the structure of a fossilized chunk of language 'once it has become automatized' (p. 221). Presumably this means that the "chunk of language" has become so embedded in the speaker's behavioral repertoire that it is difficult or impossible to modify. Others have provided more concrete operational definitions for automaticity, and these fall into four general categories, depending on whether automaticity is identified in terms of *speed* of processing, *unstoppable* processing, the *power law* or *efficient* processing.

Speed. Early on, cognitive researchers recognized that L1 processing was in some sense more automatic than L2 processing. Lambert, a pioneer in bilingualism research, wrote "automatic behavior is characterized chiefly by its speed" (1955: 197), explicitly focusing on processing speed as what chiefly distinguishes automatic from non-automatic behavior. Magiste (1986), in a study of interference across languages in bilinguals and learners of a third language, also explicitly used processing speed to make inferences about automaticity. Segalowitz (2010) further discusses how people have linked automaticity with processing speed, arguing that making such a link is an error. He argues that while automatic behavior is likely to be faster than non-automatic behavior, this cannot be the whole story because, if it were, then *automatic* would reduce to becoming a mere synonym for *fast*. If speed were the primary criterion for automaticity then we would need to establish some absolute speed-of-processing millisecond threshold that separates automatic from non-automatic performance, and it seems unlikely that this can be done. Segalowitz (2010; Segalowitz and Segalowitz, 1993) argues, instead, that the speed usually associated with automaticity is really a consequence of some other more critical feature of automatic behavior, namely the way the underlying processes are organized. According to this view, one should distinguish *speed-up* from *restructuring* (or re-organisation) explanations for so-called non-automatic and automatic behaviors respectively.

Unstoppable (ballistic) processing. An alternative to speed as a criterion for distinguishing automatic from non-automatic behavior is processing independence – that is, the immunity of automatic mechanisms to interference from other ongoing processing. The idea here is that once a process has been triggered (e.g., retrieving a word's meaning), it cannot be stopped in midstream and will run – *automatically* – to completion. Tzelgov, Henik, Sneg and Barch (1996) reported a study that illustrates just such automatic processing. They showed that Hebrew-English bilinguals could not override the processing of a word in their dominant language, even when that word was technically irrelevant to the primary task at hand. The task was a color-word interference task requiring the participant to name the color of the font of a color name word (e.g., *red* written in a green font). In the Tzelgov *et al.* study, the word itself was written with the orthography of one language (say, non-dominant English) with the phonology of the other (say, dominant Hebrew), as in the case of *adom* ["red"] in a green font where the orthography is English, the phonology is Hebrew (dominant language) and the word-color pair is incongruent (respond "green" for the font colour and ignore the meaning "red" of *adom*). They found a strong interference effect for incongruent Hebrew-phonology/English-orthography stimuli, but not for English-phonology/Hebrew-orthography, presumably because Hebrew was the participants' dominant language. This illustrates how once there had been activation of a dominant-language phonological code linked to a particular meaning, processing could not be stopped. Favreau and Segalowitz (1983) reported similar processing with French-English bilinguals in a study dissociating ballistic processing from speed of processing effects. They used a lexical decision task (judge whether a target item is a real word or not), where the target word was sometimes preceded by a to-be-ignored prime stimulus whose meaning could potentially interfere with judging the target. Participants who were more fluent in the L2 demonstrated ballistic processing in both languages whereas less fluent participants showed this in the L1 only, indicating that L2 automatic processing, but not L2 speed as such, to be associated with fluency. The upshot of these two studies is that one can operationally define automatic processing in a meaningful way as ballistic or unstoppable processing.

Power Law. Newell and Rosenbloom (1981), in a highly influential paper, argued for *a power law* of learning, according to which RT in performing a task is related to the number of practice trials; as the number of practice trials increases, RT becomes faster but with a decreasing rate of gain in speed. The exact mathematical form of the relationship has been a matter of debate (see, among others, Heathcote *et al.*, 2000; Rickard, 1997). Some L2 researchers have used the power law pattern in RT data to interpret results as evidence for automatization (DeKeyser, 1997; Ellis, and Schmidt, 1997).

Efficiency. Segalowitz (2010) argued that even if there is little consensus on how best to operationalize automaticity, the construct of automaticity nevertheless does serve a useful purpose. This is because to claim that some behavior (e.g., retrieving L2 word meaning) is automatic beyond simply being very fast, is to claim that the behavior reflects a noteworthy level of cognitive efficiency. This efficiency is achieved, presumably, through some as-yet-unspecified cognitive organization that is different from some appropriate reference point of non-automatic behavior. Segalowitz and Segalowitz (1993; Segalowitz, 2010) discuss how analysis of *intra*-individual RT variability (as opposed to *inter*-individual variability) can be used to operationalize these distinctions. This involves using the coefficient of variation (CV) of the RT – that is, the standard deviation of a person's RT divided by that person's mean RT. The CV is claimed to be a reflection of "noise" in the processing system, that is, processing variability after correcting for response speed. The lower the "noise" level, the more efficient the system can be claimed to be. Segalowitz (2010) reviews L2 processing research using this measure of processing efficiency and discusses conditions under which one can claim that a case of fast processing is more than just a reflection of simple speed-up but rather is a reflection of highly efficient processing. It is claimed that, under this view, automaticity can be operationalized by the CV when used with appropriate control procedures.

The future of automaticity in L2 acquisition research

As definitions of automaticity become more sophisticated and differentiated, the term itself seems to be evolving into more of a general umbrella construct for highly efficient performance. In this sense, automaticity appears to be losing its original sense of referring to a specific feature of cognitive processing such as parallel processing, ballistic processing, effortless processing, etc. Nevertheless, automaticity remains useful when understood in this more general sense of indicating performance reflecting more than just speed-up (where speed-up would be the null hypothesis explanation for the observed fast behavior), as long as there is a way to operationalize speed-up so that it can be rejected as the explanation for the case at hand. Of course, after rejecting a speed-up explanation in a given case, it may still be important to investigate further the exact nature of what is responsible for the significantly efficient performance. However, even without an immediate answer to that question, it is still useful to know whether a particular L2 learning context (e.g., a particular approach to instructed learning; immersion in a community of native speakers) is able to improve performance efficiency in ways that require explanation beyond simple speed-up.

As indicated in the above discussion, the meaning of automaticity in L2 research (and more generally in cognitive psychology) appears to be evolving. On the one hand, the original sense of the term may have lost some usefulness because there were too many different interpretations of what it meant to say that a behavior was automatic. It is nevertheless possible to think of automaticity as generally referring to *processing efficiency* in a way that makes possible asking whether some target behavior can be differentiated meaningfully from some reference point (such as, that the behavior can be explained in terms of simple speed-up). In this way, the study of automaticity can be useful in the study of L2 acquisition and L2 pedagogy.

See also: attention, declarative memory and knowledge, fluency, inhibitory control, procedural memory and knowledge, psycholinguistics of SLA

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Further reading

Bargh, J.A. and Williams, E.L. (2006). The automaticity of social life. *Current Directions in Psychological Science, 15*(1), 1–4. (This paper provides a good entry into the literature on automaticity as it relates to social psychology, thereby extending the discussion to an area that goes beyond general cognitive information processing issues.)

DeKeyser, R. (2001). Automaticity and automatization. In P. Robinson (ed.), *Cognition and Second Language Instruction*, pp. 125–51. Cambridge: Cambridge University Press. (This chapter provides a wide-ranging discussion of automaticity issues as they relate to second language instruction.)

Meyer, A., Wheeldon, L. and Krott, A. (eds). (2007). *Automaticity and Control in Language Processing*. New York: Psychology Press. (The 11 chapters in this volume discuss automaticity from different perspectives, providing the reader with an appreciation of the applicability of the construct to a wide variety of language-based situations.)

Moors, A. and De Houwer, J. (2006). Automaticity: a theoretical and conceptual analysis. *Psychological Bulletin, 132*(2), 297–326. (This article provides a detailed look into the concept of automaticity from a general cognitive psychological perspective.)

Segalowitz, N. and Hulstijn, J. (2005). Automaticity in bilingualism and second language learning. In J.F. Kroll and A.M. B. De Groot (eds), *Handbook of Bilingualism: Psycholinguistic Approaches*, pp. 371–88. Oxford: Oxford University Press. (This chapter provides an extended overview of automaticity issues as they relate specifically to second language acquisition and to bilingualism).