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ALERTNESS, ORIENTATION, AND DETECTION

The Conceptualization of Attentional Functions in SLA

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This paper critically examines Tomlin and Villa's (1994) fine-grained analysis of attention and Leow's (1998) attempt to operationalize their model. Our position is that whereas Tomlin and Villa have moved the attention research forward by describing the nature of attentional processes and by pointing out that detection is a critical function of SLA, their claim that alertness and orientation are not necessary for detection to occur is currently unsupportable and does not reflect the complex nature of SLA. We argue that Leow's efforts to provide empirical support for this model fall short of that goal. Additionally, we cast doubt on Tomlin and Villa's position that awareness is not required for the detection of L2 data by arguing that the issue of awareness as well as the role of attentional functions must be viewed from a more interactive perspective in terms of the nature of the task, the nature of the linguistic item, and individual learner differences. We conclude by proposing research orientations that may help advance the discussion on this topic.

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The role of attention in language processing has become the focus of a rich corpus of recent second language acquisition (SLA) studies. As the field of SLA research enters the new millennium, it is becoming increasingly clear that the role of attention is as important to understanding SLA as the role of input. As summarized by Schmidt (in press), it is now recognized that attention is a necessary construct for understanding virtually every aspect of SLA.

The relationship between attention and learning has long been a topic of great interest and the focus of research in cognitive psychology (e.g., Allport, 1988, 1989; Cowan, 1995; Dulany, Carlson, & Dewey, 1984; Logan, 1988, 1990; Mathews et al., 1989; Perruchet & Pacteau, 1990, 1991; Reber, 1967, 1976, 1989, 1993). In the field of SLA, the role of attention was first couched in the discussions of the role of unconscious and conscious processes in SLA, with attention being intimately tied to the latter (Bialystok, 1978, 1981a, 1981b, 1981c; Krashen, 1978, 1981, 1982, 1985). In the literature on consciousness-raising or input enhancement (Sharwood Smith, 1981, 1991, 1993) and focus on form (e.g., Doughty, 1991; Lightbown & Spada, 1990; Long, 1983, 1996; VanPatten, 1990), both indirect and direct appeals can be found regarding the proposed benefits of attending to input and SLA, but attention was not necessarily isolated as the focus of discussion. VanPatten (1989, 1990) brought the discussion of attention to the forefront by providing empirical evidence to demonstrate how learners allocate attentional resources to input when required to process input for form and meaning at the same time. In reaction to the argument of McLaughlin, Rossman, and Mcleod (1983) and McLaughlin (1990) that the term consciousness "has acquired too much surplus meaning" to be of any use to SLA (McLaughlin, 1990, p. 617), Schmidt (1990, 1992, 1993, 1994) added another layer to the discussion by addressing attention as one form of consciousness and by his explicit claim that learners must consciously pay attention to or *notice* input in order for second language (L2) data to become intake.

The work of Tomlin and Villa (1994) further focused the discussion on the role of attention in SLA by pointing out that before we can have a clear picture of what role attention plays during input processing, the processes involved in attention must first be more precisely defined. Appealing to research from cognitive psychology and neuroscience, they present a fine-grained analysis of attention in which two important claims are made: (a) that attention involves at least three theoretically and empirically separable functions (alertness, orientation, and detection); and (b) that awareness can be dissociated from attention (p. 198).

Tomlin and Villa's (1994) model has made an important contribution to SLA by describing some of the central processes that make up the construct of attention (e.g., alertness, orientation, and detection) and thereby encouraging more focused research on this topic. The impact of this work is evident as it has been cited as a theoretical motivation for recent studies of input enhancement and especially of textual enhancement in SLA (e.g., Alanen, 1995; Jourdenais, Ota, Stauffer, Boyson, & Doughty, 1995; Leeman, Arteagoitia, Fridman, &

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Doughty, 1995; White, 1996, 1998). Drawing on Tomlin and Villa's position that detection of input is a necessary and sufficient condition for further processing, input enhancement studies are investigating different ways of drawing learners' attention to specific features of language input in order to facilitate their detection. In a recent attempt to operationalize their model, Leow (1998) further contributed to making Tomlin and Villa a pivotal work of the attention literature in SLA with the claim that this study provided empirical evidence to support the fine-grained analysis of attention.

Given that much of the process of SLA is driven by cognitive activity, Tomlin and Villa (1994) are correct to point out that the field of SLA can only gain from insights from cognitive psychology and neuroscience. However, we must question the validity of applying a model that is based on findings from the research contexts of psychology and neuroscience to SLA and the feasibility of operationalizing concepts taken from these disciplines for SLA.

This paper critically examines the two claims made by Tomlin and Villa (1994) in their fine-grained analysis of attention and Leow's (1998) attempt to operationalize their model. Our position is that although Tomlin and Villa have moved the attention research forward by describing the nature of attentional processes and by pointing out that detection is a critical function of SLA, their claim that alertness and orientation are not necessary for detection to occur is currently unsupportable and does not reflect the complex nature of SLA. We argue that Leow's efforts to provide empirical support for this model fall short of that goal. Additionally, we cast doubt on Tomlin and Villa's position that awareness is not required for the detection of L2 data by arguing that the issue of awareness as well as the role of attentional functions must be viewed from a more interactive perspective in terms of the nature of the task, the nature of the linguistic item, and individual learner differences.

Although a few years have passed since Tomlin and Villa's work was published in 1994, it is important to address the claims made by the fine-grained analysis of attention, because this work continues to be frequently cited in SLA research, particularly in the input enhancement literature. As interest in input enhancement and, specifically, textual enhancement research increases (Wong & Simard, 1999), SLA researchers can only benefit from a clarification of one of the influential underpinnings of such research.

This paper first presents the fine-grained analysis of attention. We then critically discuss the two conclusions reached by Tomlin and Villa (1994) by examining selected studies from neuroscience and cognitive psychology, the research on which the fine-grained analysis of attention is based. We also examine Leow's (1998) attempt to operationalize Tomlin and Villa's model and, in so doing, demonstrate how this study does not successfully provide support for the claims made by the fine-grained analysis of attention. After reviewing the evidence, we propose suggestions for a conceptualization of awareness and attentional functions that reflects the complex nature of SLA more accurately and conclude with proposals for new research orientations in this area.

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TOMLIN AND VILLA'S MODEL

In an effort to encourage SLA researchers to investigate the role of attention more formally, Tomlin and Villa (1994) proposed a fine-grained analysis of attention that draws on research from cognitive psychology and neuroscience, primarily the work of Posner and Petersen (1990). According to Tomlin and Villa, concepts such as limited capacity (Broadbent, 1958; Kahneman, 1973; McLaughlin, 1987; McLaughlin et al., 1983; Wickens, 1984, 1989), selective capacity, and automatic and controlled processing (Bialystok, 1978, 1981a, 1981b, 1981c, 1988, 1990; Bialystok & Sharwood Smith, 1985; McLaughlin et al., 1983) are coarse-grained because they do not specify exactly how attention is committed to a given task or processing of stimuli (Tomlin & Villa, 1994, p. 194). They posited that their fine-grained model of attention integrates these related conceptions of attention into a system that allows the investigation of language data at the moment of acquisition (p. 190).

Drawing on the work of Posner and Petersen (1990), Tomlin and Villa (1994) identified three functions that are involved in attention: alertness, orientation, and detection. They defined *alertness* as an overall, general readiness to deal with incoming stimuli or data, and this function is directly related to the rate at which information is selected for further processing (p. 190). However, they pointed out that a higher level of alertness may lead to a lower level of accuracy. According to Tomlin and Villa, the attentional process of alertness does not have a very important role to play in SLA. Alertness is only of general import to SLA in that learners usually have to be ready to process information (p. 191).

Orientation is defined as the attentional process responsible for directing attentional resources to some type or class of sensory information at the exclusion of others (Tomlin & Villa, 1994, p. 191). The authors claimed that this component of attention is of greater importance to SLA than alertness is. When attention is directed to a particular piece of information, detection is generally facilitated. Orientation can have either a positive or negative effect, on their account, depending on whether the information that attentional resources are focused on is expected (positive effect) or not (negative effect).

The third function of attention, *detection*, refers to "the cognitive registration of sensory stimuli" and is "the process that selects, or engages, a particular and specific bit of information" (Tomlin & Villa, 1994, p. 192). According to the authors, detected information causes great interference with the processing of other information and exhausts more attentional resources than even orientation of attention. For Tomlin and Villa, detection is the attentional process that is responsible for intake derivation of L2 input. They stated that once information is detected, then further processing of that information is possible. Thus, detection is the most important function of attention for language processing. The authors further suggested that these three functions of attention can be isolated. They claimed that although alertness and orienta-

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tion may together or separately enhance detection, neither of these attentional processes is a prerequisite for detection to occur (p. 197).

The second important claim that Tomlin and Villa (1994) have made is that awareness, which they define as "the subjective experience of any cognitive or external stimulus," (p. 194) can be dissociated from attention. They claimed that awareness is not required for any of the three functions of attention that they discuss.

Tomlin and Villa's (1994) conclusion that attention involves three interrelated yet separable attentional functions has contributed to SLA research by breaking down the construct of attention into more precise functions. Additionally, because of their proposal that attention may be dissociated from awareness, the discussion has shifted from a debate on whether SLA involves primarily conscious or unconscious processes to a discussion on the importance of attention (which may or may not require awareness) and, in turn, on the proposed benefits of focus on form and input enhancement. If attention is now recognized as a crucial construct to understanding all aspects of SLA, as Schmidt (in press) recently proposed, it is perhaps in part due to the work of Tomlin and Villa. However, we maintain that their use of the neuroscience and psychology research to draw their conclusions is problematic for several reasons. In the following sections, their two claims and the research used to make these claims are discussed in greater detail, in order to address the feasibility of using the fine-grained model to investigate the role of attention in SLA.

THE SEPARATION OF THE THREE FUNCTIONS OF ATTENTION

In pointing out that detection is the crucial process for language acquisition, Tomlin and Villa (1994) also stressed that alertness and orientation can be isolated from each other: "Attention involves at least three theoretically and empirically separable components: alertness, orientation and detection" (p. 198). Additionally, the authors posited that alertness and orientation are not required for detection: "Both orientation and alertness may separately or together enhance the chances for detection to occur, but neither is required" (p. 197). Tomlin and Villa based their position regarding the possible separation of these attentional functions on the work of Posner and his colleagues (Posner & Petersen, 1990; Posner & Rothbart, 1992) in neuroscience. Given that language acquisition is primarily a cognitive activity, it would be fruitful to consult such research in order to enrich our understanding of how different parts of the brain function to carry out various cognitive processes. However, making direct comparisons from one domain to another is not always prudent. To demonstrate why using the neuroscience literature to draw conclusions about attention and SLA is problematic, we present the research context in which the separability of the attentional functions was studied in neuroscience in the following section.

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Table 1. Networks, components, and functions of attention

Network	Anatomical components	Function
Posterior	Portions of parietal cortex, associated thalamic areas of the pulvinar and reticular nuclei, and parts of the midbrain's superior collicus.	Orienting attention to visual locations
Anterior	Areas of the midprefrontal cortex including the anterior cingulate and the closely related but more superior supplementary motor area.	Detecting target events
Vigilance	Involves norepinephrine input to the cortex. Most active in the right front lateral lobe.	Maintaining the alert state

Separability of Attentional Functions in Neuroscience

Posner and his colleagues (Posner 1992, 1994, 1995; Posner & Petersen, 1990; Posner & Rothbart, 1992) have stated that there are at least three main functions involved in the process of attention:

> It is not possible to specify the complete attentional system of the brain, but something is known about the areas that carry on three major attentional functions: orienting to sensory stimuli, particularly locations in visual space; detecting target events, whether sensory or from memory; and maintaining the alert state. (Posner, 1995, p. 617; see also Posner & Petersen, 1990, p. 26)

The main objective of Posner and his associates' work was to investigate if these three functions of attention are localized in different parts of the animal and human brain. It was hoped that by identifying the components of the brain responsible for different attentional processes and by examining how the attentional networks affect other cognitive systems, more progress could be made in treating pathologies linked to attentional disorders. Through advances in research technology, particularly neuroimaging techniques, such as positron emission tomography (PET), Posner and his colleagues were able to trace the three functions of attention to three different attentional networks as well as identify the components of the brain that make up each network (see Table 1).

By introducing a small amount of radioactivity into the body of primates and human beings, blood flow in different brain regions could be measured by detectors outside the head. These PET studies revealed that when subjects had to orient their attention from one visual location to another, blood flow increased in the components of the posterior network. These components include portions of the parietal cortex, associated thalamic areas of the pulvinar

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and reticular nuclei, and parts of the midbrain's superior collicus. However, when a target stimulus was detected by a subject, or when a subject had to orient attention to nonlocational features of a stimulus, it was the anterior network that was activated. This anterior network was found to be made up of the midprefrontal cortex, the anterior cingulate, and the more superior supplementary motor area. Finally, it was found that the vigilance network responsible for maintaining the alert state was due to input from the neurotransmitter norepinephrine and this neurotransmitter was found to be especially active in the right cerebral hemisphere.

Posner and his colleagues claimed that although the separate components of each network perform different functions, they also have strong anatomical ties to each other and work together to carry out each network's main function of alerting, orienting, and detecting (Posner & Rothbart, 1992). However, there is also evidence that under certain circumstances, a certain level of independence is possible in the development and functions of the networks. The degree of the networks' independence depends on the nature of the task and the amount of online mental activity required to perform the task (Posner & Rothbart).

Separability of the Functions and SLA Research

The work of Posner and his colleagues has been instrumental to the progress made in attention research in neuroscience and cognitive psychology. The contribution of this research to SLA, however, is currently limited due to different research contexts and the difficulty of finding operational definitions for the attentional functions in SLA.

First, it is important to point out that Posner and his associates' work does not address language acquisition. One of their goals was to investigate how the attentional networks might affect the performance of other cognitive networks in the human brain. However, to our knowledge, the only other cognitive systems that have been examined in conjunction with the attentional networks in Posner and his colleagues' work have been the pattern recognition system (Posner, 1994), the L1 word recognition system (Posner, Petersen, Fox, & Raicle, 1988) and the semantic system (Posner, 1992). It is not clear how such systems might inform us about how attention might affect L2 learning. Because the acquisition of an L2 as a cognitive system has not been investigated, much still remains to be known about how the three attentional functions might influence the processing of L2 input. Therefore, any claims about the separability of the attentional functions in SLA tasks are probably premature. Second, it is important to indicate that when Posner and his associates make reference to the posterior attentional network and its associated function of orientation, their references are limited to orienting to visual locations (Posner, 1995; Posner & Petersen, 1990; Posner & Rothbart, 1992). For example, subjects may be asked to search for a vertical triangle in an array of

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distractors (Posner, 1994). Orienting to nonlocational features of stimuli such as color, form, motion, or word semantics does not take place in the posterior system and has not been as extensively researched by neuroscientists (Posner, 1994). Whereas work with spatial orienting proved to be fruitful for the purposes of neuroscience research, this type of orienting is only of limited use to SLA. Orienting to visual locations in space has little or nothing to do with the need for learners to direct their attentional resources to features of L2 input to facilitate their intake of that input.

Third, it is important to clarify that when Posner and his associates talk about the subsystems of attention as separable, the emphasis is on the fact that the three networks of attention (posterior, anterior, and vigilance) and the different brain areas that make up each network are anatomically separable and perform different functions. This is not synonymous with saying that the functions of alerting and orienting (to all kinds of stimuli) can be isolated from each other or that these two attentional functions are not required for detection to occur. To our knowledge, this possibility has not been addressed in their work. To date, only the isolation of orienting to visual locations and detection has been documented (Pashler, 1993). The possible separation of alertness and orienting to nonlocational aspects of stimuli (e.g., language data) and detection has not yet been examined. In a personal communication (November 11 & 12, 1998), M. I. Posner stated that all three attentional networks are usually activated at once to carry out detection and pointed out that it would be extremely tricky to design tasks to study their separate properties. With the exception of orienting to visual locations, it would be very difficult to demonstrate that when a subject is detecting targets, she or he is not also oriented to the relevant features of the targets, given that orienting to nonlocational features of input and the detection of that input both take place in the anterior network. Posner stated that particularly in higher order level tasks that involve processing language data, all three functions of attention are usually activated at the same time.

Finally, to assess the contribution of each attentional function to SLA and to make the claim that alertness and orientation are not required for detection to occur, researchers need to be able to observe the separate effects of each function in a task that involves processing L2 input. Given the difficulty of operationalizing the attentional functions separately in neuroscience research, it does not appear that such a task can be accomplished in SLA research with the instruments currently available. It would be tricky enough to isolate what subjects are detecting during a language processing task. Designing a task that could adequately examine the isolated effects of alertness and orientation during detection of L2 input seems virtually impossible.

One SLA study, Leow (1998), attempted to operationalize the fine-grained analysis of attention. Although this study claimed to have found empirical support for Tomlin and Villa's (1994) model, we argue in the next section that methodological flaws due to the difficulty of isolating the three attentional functions in an SLA task weaken the evidence.

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Table 2. Summary of Leow's (1998) treatment and control groups

Groups	Treatments
1 (Control group)	+alertness, –orientation, –detection
2	+alertness, +orientation, –detection
3	+alertness, +orientation, +detection
4	+alertness, –orientation, +detection

OPERATIONALIZING THE FINE-GRAINED ANALYSIS OF ATTENTION

Leow (1998) set out to isolate the effects of the three components of attention at a morphosyntactic level via a problem-solving task, specifically crossword puzzles. Leow designed "four crossword puzzles . . . to isolate the effects of the three attentional functions of alertness, orientation, and detection" (p. 137). The target structure under investigation was the irregular third-person singular and plural preterit forms of stem-changing *-ir* verbs in Spanish. The treatment groups and control group are given in Table 2.

As Table 2 shows, alertness was not isolated as a variable in the Leow (1998) study; it was present in every condition. Orientation was operationalized with the following bolded sentence in the instructions: "Please note that some of the forms of the verbs are irregular" (Groups 2 and 3). To measure the inhibitory effects of orientation, the puzzle for Group 2 oriented subjects' attention to the incorrect verb form. The puzzle for Group 3 was designed to measure both the facilitative effects of orientation to and detection of grammatical target forms. This was done by ensuring that the stem changing vowels in the irregular forms would be provided by other clues known to the learners (Leow, p. 138). To measure the effects of detection without orientation (Group 4), Leow used the same puzzle as the puzzle for Group 3 but omitted the bolded sentence in the instructions orienting subjects' attention to the targeted items. Intake was measured via an immediate and a delayed posttest. These were a recognition task and a written production task. Detection was further measured by using subjects' think-aloud protocols.

Leow's (1998) results revealed that Group 3 (+alertness, +orientation, +detection) and Group 4 (+alertness, –orientation, +detection) performed significantly better on all immediate and delayed posttests than Group 2 (+alertness, +orientation, –detection) and the control group (+alertness, –orientation, –detection). However, there were no differences in performance between Group 3 and Group 4 and between Group 2 and the control group. Leow concluded that these results show that detection is the crucial attentional process for intake. Subjects in the [+detection] groups (Group 3 and Group 4) were able to take in and produce significantly more correct linguistic forms

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than learners in the [–detection] conditions (Group 2 and the control group). Leow stated that these findings were also confirmed by the think-aloud protocols. A review of these protocols for all four groups revealed that only Group 3 and Group 4 showed instances of further processing of the detected forms. Leow further concluded that the poorer performances of Group 2 (+alertness, +orientation, –detection) and the control group (+alertness, –orientation, –detection) and the lack of significant difference between them "clearly indicate that alertness and orientation are not crucial in enhancing detection at a morpho-syntactic level when occurring alone" (p. 146), providing support for Tomlin and Villa's (1994) fine-grained analysis of attention. Leow added that the superior performance of Group 4 (+alertness, –orientation, +detection) further supports this claim, because it appears that the absence of orientation did not inhibit the subjects in this group to detect the target forms. Finally, Leow stated that the findings of the study also support Tomlin and Villa's (1994) prediction that orientation can have facilitative effects (cf. the performance of Group 3) for detection to occur or inhibitory consequences when the information received does not occur as expected (see the performance of Group 2, whose attention was aligned on the incorrect choice) (p. 146).

Although Leow's (1998) conclusion was that the findings of his study "lend strong empirical support, at a morpho-syntactic level, to Tomlin and Villa's (1994) fine-grained analysis of attention" (pp. 147–148), we argue that owing to certain methodological problems, this is not the case. First, the only assessable definition Leow provided for the functions of attention is for detection, operationalized as "making a written or verbal correction of the targeted forms . . . and/or commenting on the targeted linguistic forms" (p. 136). Leow did not provide clear operational definitions for the other two functions of attention that the study attempted to isolate. For the definition of alertness, Leow cited Tomlin and Villa (1994), stating that this refers to "an overall readiness to deal with incoming stimuli" (Leow, 1998, p. 135; Tomlin & Villa, p. 190). However, Leow did not actually operationalize alertness because there is no assessment of alertness. In fact, as pointed out earlier in this section, alertness was never even isolated as a variable in this study as this attentional function was never absent in any of the three treatment groups or the control group. Thus, because alertness was always present as a covariable with orientation and detection in this study, Leow cannot make the claim that "the model's [Tomlin and Villa's] three attentional functions of alertness, orientation, and detection were isolated" (p. 148) or that this study provides evidence that "alertness and/or orientation did not appear to be required to enhance detection when occurring alone" (p. 146).

Perhaps the reason why alertness was not isolated in this study is due to the fact that it is virtually impossible to design a task, particularly a language processing task, to do so. Recall that Posner and Petersen (1990) stressed that the attentional networks cooperate to carry out tasks. Although alertness as a function by itself may not be crucial to SLA, the alert state may need to be

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maintained in order to activate orientation and detection in complex tasks such as the ones Leow (1998) used in the study.

Second, though the absence of orientation did appear as a variable in Leow's (1998) study, it is not entirely true that the subjects in the [–orientation] groups (Group 4 and the control group) were not also oriented to the verbs. Orientation is defined by Leow as "the direction of attentional resources to a certain type of stimuli" (Leow, p. 135; Tomlin & Villa, 1994, p. 190) and was operationalized by providing subjects in the [+orientation] groups (Group 2 and Group 3) with the bolded sentence "Please note that some of the forms of the verbs are IRREGULAR" in the instructions. We argue that this sentence is not an effective way to operationalize orientation, because this technique does not allow for the actual measurement of orientation. Because subjects' attention to this sentence was not assessed, we cannot know for sure that all the subjects who received this bolded sentence paid attention to it. Furthermore, if orientation is "the direction of attentional resources to a certain type of stimuli," then we can also conclude that the subjects in all four groups were oriented to the verbs, given that all the target verbs were italicized in all four puzzles. The use of italics (or any other type of textual enhancement technique such as bolding, underlining, etc.) represents attempts to draw subjects' attention to specific stimuli (Wong & Simard, 1999). In this way, then, we can say that there was an attempt to direct the subjects' attentional resources to these target verbs in all four puzzles.

One could perhaps argue that the bolded sentence for the [+orientation] groups contained an extra clue (that some verbs were irregular) that might help the subjects complete the task, and, consequently, orient their attention to the targets to a higher degree (assuming that they saw and processed this sentence), but it cannot be said that the subjects who did not get this bolded sentence were not also oriented. Therefore, it would be more appropriate to talk about the degrees of orientation present in this study than to claim that orientation was isolated as a variable. Furthermore, although the presence of alertness and orientation may not guarantee detection, it has not been demonstrated that alertness and orientation can be absent at the moment of detection in language-processing tasks such as the ones Leow (1998) used. In other words, it may be possible for alertness and orientation to exist without detecting a target, but there is no evidence to suggest that detection can occur without also activating alertness and orientation in language processing tasks. Thus, the reason why no significant differences were found between Group 3 (+alertness, +orientation, +detection) and Group 4 (+alertness, –orientation, +detection) may not be due to the fact that orientation is not crucial for detection, but because the treatments used in these two groups were not really all that different to begin with. With or without that bolded sentence, both Group 3 and Group 4 could have been in an alert state and oriented to the targets at the moment of their detection. There is no evidence in Leow's study to show that this was not the case.

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Thus, Leow (1998) does not lend empirical support to the fine-grained analysis of attention for the following reasons: (a) The study did not show that alertness may be isolated from the other two attentional functions, and (b) the study did not successfully demonstrate that orientation can be isolated from the other two attentional functions and that it is, consequently, not crucial for detection to occur.

In light of the criticisms made in this paper, we propose that these limitations in Leow's (1998) research design may be due to Tomlin and Villa's (1994) interpretation of Posner and his associates' work. Recall that although Posner and his colleagues have stated that separable anatomical networks are responsible for carrying out the different functions of attention, they never imply that certain tasks will not require the cooperation of alertness, orientation, and detection. In fact, although this has not been specifically examined, Posner himself has expressed that higher order tasks that involve language processing will most probably require that all three attentional functions work together (M. I. Posner, personal communication, November 11 & 12, 1998). Furthermore, the definition of orientation as used in the neuroscience research is very different from how Leow attempted to operationalize it in the context of SLA. As brought out in the previous discussions, orientation was examined in the neuroscience research only in relation to how subjects allocated attention to visual spatial locations. The role of orientation in tasks that require subjects to direct attention to nonlocational aspects of input has not been thoroughly studied by Posner and his associates. The only documented evidence of functional independence between attentional networks is in dual task contexts where one of the tasks involves orienting to visual locations (Pashler, 1993). In such cases, some level of independence between networks is possible, because the function of orienting to visual locations takes place in the posterior network, a network that is anatomically separate from the network that is responsible for target detection, the anterior network. Orientation in Leow's study, however, did not involve orienting to visual locations. Leow attempted to orient the subjects' attention to the irregular forms of Spanish verbs. According to Posner and his associates, this type of orienting (orienting to nonlocational features of input) would take place in the same network responsible for detection, the anterior network. There is currently no evidence to show that orienting to nonlocational features of input can be isolated from the detection of that input. This possibility would be extremely difficult to demonstrate given that both functions in this case take place in the same anterior network. As for the function of maintaining the alert state, this variable does not appear to be separable in language tasks, given that Leow did not attempt to isolate it from the other two functions in the study.

Therefore, we maintain that there is no evidence to suggest that the fine-grained analysis of attention in SLA can be operationalized in SLA. Although detection may be the attentional function responsible for further language processing, Tomlin and Villa's (1994) claim that "neither awareness nor alertness nor orientation is required for detection to occur" (p. 198) remains unval-

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idated. Leow (1998) represents a noteworthy effort to provide empirical support for this position, but, as we have argued, due to flaws in the research design, the conclusions cannot be taken as evidence for Tomlin and Villa's model. In the following section, we turn our attention to the second claim of Tomlin and Villa's work, that detection can be dissociated from awareness.

DISSOCIATION OF AWARENESS FROM DETECTION

In pointing out that detection is the attentional function responsible for intake derivation, Tomlin and Villa (1994) maintained that awareness is not required for detection or for any of the other two attentional functions to occur:

> None of the central components of attention—alertness, orientation, or detection—require awareness, either to operate or as the result of processing. Detection is the most related to awareness, but there is considerable evidence indicating that information can be cognitively detected even though the individual is not aware of it having occurred. (p. 193)

Tomlin and Villa are correct to point out that there are studies in the cognitive psychology literature to suggest that, under certain task conditions, subjects can detect certain types of stimuli in the absence of awareness (Allport, 1977; Baylis, Driver, & Rafal, 1993; Corteen & Wood, 1972; Lewicki, Czyzewska, & Hoffman, 1987; Lewicki, Hill, & Bizot, 1988; Willingham, Greeley, & Bardone, 1993; Wilingham, Nissen, & Bullemer, 1989). However, as many researchers have argued (e.g., Robinson, 1996a, 1996b; Schmidt, 1995; Schwartz, 1986; VanPatten, 1996), there are many problems with using this type of research to draw conclusions about the role of awareness in SLA. Because there are already several good papers that address the issue of generalizing findings from psychology to SLA in regards to the issue of awareness (Robinson, 1996a, 1996b; Schmidt, 1995; VanPatten, 1994), we will not repeat their efforts here with a detailed review of the psychology literature. However, we feel it is important to discuss the three works that Tomlin and Villa cited to make their argument (Carr & Curran, 1994; Curran & Keele, 1993; Marcel, 1983), in order to demonstrate more concretely why their claim concerning the role of awareness in SLA needs to be reevaluated.

The first work that Tomlin and Villa (1994) cited is Marcel's (1983) study of lexical priming. In this study, it was found that subjects were able to accept target words more rapidly as measured by reaction-time tasks when they were first presented with semantically related priming words of 4–8 letters long that were visible from 30 to 80 milliseconds on a screen. Because subjects were not able to report above chance that they had seen the priming words prior to accepting the target words, the conclusion was that they were not aware of having seen the priming words. Tomlin and Villa's interpretation of this study was that this "shows that people can cognitively process words yet not be aware of those words" (p. 193), and hence their conclusion that detection does not necessarily involve awareness in SLA.

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Many researchers (Schmidt, 1995; Shanks & St. John, 1994; VanPatten, 1996) have cautioned that Marcel (1983) and other studies of lexical priming may not be applicable to the issue of learning and awareness in SLA. VanPatten (1996), for example, has argued that one of the problems with this study is that subjects were not L2 learners but adult native speakers who already have a fully developed semantic and lexical system (p. 44). They were asked to process not grammatical items but lexical items that they had already learned and stored in long-term memory. Shanks and St. John have pointed out that because exposure time to these words was only a few hundred milliseconds, the registration of this stimuli was unlikely to have any effect on any task beyond the immediate recognition of already familiar words. According to the authors, if unconscious learning is to have any real significance, it must be demonstrable over reasonable intervals of time (1994, p. 370). They suggested that, at the very least, exposure time must last from a few seconds to minutes rather than milliseconds. Solso (1998) called the processing stage that deals with the persistence of visual impression "representation in iconic memory" and pointed out that this is independent of higher-order processes such as attention. According to Solso, storage of visual information (such as subliminal word priming) is not directly related to information processing. Therefore, we argue that Marcel (1983) and other studies of this nature cannot be taken as evidence for the position that detection of novel language input does not necessarily involve awareness.

Citing Curran and Keele (1993) and Carr and Curran (1994), Tomlin and Villa (1994) stated that "even more relevant for SLA is work that shows that subjects can learn a repeating sequence but not be aware of that sequence" (p. 193). It is not clear why the authors chose to cite these two articles to make their argument concerning the role of awareness and SLA. First, it must be mentioned that Carr and Curran was not an empirical study but a review article on the sequential and artificial grammar learning literature. Interestingly enough, these authors themselves caution against generalizing results from such studies to SLA. They specifically pointed out that the task demands and learning conditions of finite-state grammar learning do not match those of natural language acquisition (1994, p. 207). Other researchers have made similar arguments by pointing out that artificial grammars lack important features that characterize natural languages, such as the absence of a semantic component, the lack of surface features that encode morphological form, agreement mapping and phonological inflections, and the absence of rules that dictate and restrict syntactic movement (Robinson, 1996a, 1996b; Schmidt, 1995; VanPatten, 1994, 1996).

Second, it is important to point out that Curran and Keele (1993) did not claim in their study that awareness is not required for learning. In fact, their research question was not whether awareness may be dissociated from learning but whether there can exist a nonattentional mode of learning. They do, however, bring up the issue of awareness in their discussion and, as also observed by Schmidt (1995, p. 27), Curran and Keele did not report that their

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subjects were unaware of what they learned. The researchers classified their subjects as "more aware" and "less aware" on the basis of subjects' self-reports. The results from their single-task experiment showed that subjects who were classified as more aware learned more than those who were less aware. Thus, this study did not show that there can be learning in the absence of awareness. On the contrary, the findings of Curran and Keele suggested that higher degrees of awareness lead to more learning.

Therefore, the three cognitive psychology studies that Tomlin and Villa (1994) cited, and other studies of this nature, should not be taken as evidence for the position that detection of L2 input for further language processing does not necessarily involve awareness. Although there exists a corpus of studies in the cognitive psychology literature to suggest that awareness may be dissociated from detection under certain conditions, the stimuli and tasks used in this type of research do not allow their conclusions to be generalizable to the complex nature of SLA. Presently, the role of awareness in SLA remains difficult to untangle because the task of finding appropriate operational definitions for this construct remains a challenge.

RECONCEPTUALIZING ATTENTION

As pointed out in the beginning of this paper, Tomlin and Villa's (1994) fine-grained analysis of attention has advanced the attention literature in SLA by describing the processes that are involved in attention. In so doing, they have provided researchers with a deeper understanding of the nature of attentional processes in SLA. However, given the research context on which the fine-grained analysis of attention is based and the difficulty (or perhaps impossibility) of operationalizing its claims, we need to reconceptualize this model in a way that is more appropriate for the context of SLA.

Just as we cannot expect a single theory to ever completely explain the nature of attention in human information processing, we cannot expect a single model to ever completely account for the allocation of attention during L2 input processing. However, there are certain variables that models of attention need to account for in order to conceptualize the role of attention in SLA more adequately. The first variable is task type. In L2 learning and research contexts, learners may engage in a variety of language tasks such as recognition tasks, memory tasks, comprehension tasks, verbal reports, grammatical judgment tasks, rule formation tasks, or other kinds of production tasks. Because the goal of each task influences what is attended to, attention demands will necessarily be different for different tasks (Kanwisher, Driver, & Machado, 1995; Robinson, 1996a, 1996b; Style, 1997; Tipper, Weaver, Jerreat, & Burak, 1994). Thus, it appears unlikely that the functions of attention and awareness can be always absent or present to the same degree when L2 input is detected.

Another variable that must be considered is the linguistic item in question. Given that not all features of language are learned the same way (Ellis, 1994a, 1994b; Robinson, 1996a, 1996b; Schmidt, 1995; Schwartz, 1993; VanPatten,

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1994, 1996), it should not be assumed that the same level of alertness, orientation, and awareness are present (or absent) in learning every subsystem of language. Schmidt, for example, predicted that learning the lexicon, fixed formulaic expressions, and bound morphemes may require less attention than other features (1995, p. 15). Schwartz posited that whereas the learning of lexical items may favor the use of explicit information to draw learners' attention to the necessary input, the learning of syntax can only make use of attention to available positive evidence. Whether one agrees with the position of these researchers and the linguistic examples presented is not the issue here. What is essential is that attentional processes do not operate in the same way and to the same degree for learning every subsystem of language.

Finally, a model of attention for SLA needs to account for the variable of individual differences. Factors such as learner motivation, learning style, and memory span have been known to affect how input is processed by individual learners (Schmidt, in press; Skehan, 1989). Furthermore, because individual learners may have different levels of attentional processing capacity (Kanfer & Ackerman, 1989; VanPatten, 1990, 1996; Wickens, 1984, 1989), awareness and the attentional functions cannot be expected to operate in the same way for all L2 learners.

Given that all these variables can influence attentional demands in L2 input processing, we posit that a model of attention for SLA needs to allow for graded degrees of activation of attention and awareness. There exists research from psychology and SLA to suggest that attention and awareness are not all-or-none entities but are instead "graded properties." It is not within the scope of this paper to provide an extensive review of this literature, but we would like to cite a few noteworthy works here.

In a review of the neural and cognitive psychology research, Farah (1992) made reference to the graded nature of the activation of attention by pointing out that information represented in neural networks may be "partially represented" (p. 40). In a study by Gati and Ben-Shakhar (1990), the researchers were able to measure the magnitude of orienting via skin conductance responsivity and concluded that the *degree* of orienting was a function of the novelty and importance of the stimuli to participants (p. 257). After reviewing the evidence from psychology, Cowan (1995) posited that we must theoretically be able to speak of the possibility of graded amounts of awareness and attention (p. 200). According to Cowan, it is possible that the difference between activated information inside versus outside of the focus of attention is "a matter of the level of activation" (p. 33). Additionally, as found by Curran and Keele (1993) and discussed earlier in this paper, task performance may be a function of greater or lesser degrees of awareness that are reportable by participants.

In SLA research, a number of studies have demonstrated that different degrees of attention paid to L2 input can lead to more or less learning. In a study using crossword puzzle tasks and think-aloud protocols, Leow (1997) found that different levels of awareness led to differences in processing. Leow observed that more awareness contributed to more recognition and accurate

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production of the noticed irregular preterit Spanish verb forms. Hauser (1999) investigated the development of awareness among Japanese ESL learners' rules of thumb regarding the use of definite articles with place names and found a strong relationship between awareness and improved learner performance. Rosa and O'Neill (1999) exposed L2 Spanish learners to five different degrees of explicitness and found that higher levels of awareness resulted in stronger effects on intake.

Therefore, rather than viewing alertness, orientation, detection, and awareness as separate and discrete all-or-none entities, we posit that a model of attention that more accurately reflects the complex nature of SLA is one in which awareness and attentional functions are viewed as being present in graded amounts, and whose degree of activation is influenced by the interactions among task type, linguistic items, individual differences (such as processing capacity), and by any other concurrent cognitive activity competing for processing resources.

CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH

Our goal in this paper was to critically examine the two claims made by the fine-grained analysis of attention in order to address the appropriateness of using such a model to advance research in SLA. We brought out the contribution that the work of Tomlin and Villa (1994) has made to the attention literature in SLA. By breaking down the construct of attention into more precise functions, they have provided SLA researchers with a richer understanding of the nature of attentional processes. However, our review of the psychology studies on which this model is based, as well as Leow's (1998) attempt to provide empirical support for this model, led us to conclude that the way in which awareness and the three attentional functions are currently represented by the fine-grained model of attention may not be generalizable to the context of SLA. Furthermore, we brought out that the conceptualizations of attention and awareness posited by the model do not adequately reflect the complex nature of the relationship between attentional processes and SLA. Given that a variety of variables may influence attentional demands during L2 input processing, we proposed that a more feasible way to conceptualize attention is not to view alertness, orientation, detection, and awareness as always separable, but as coexisting and interacting in graded levels, and whose degree of activation is determined by the nature of the task, the linguistic item in question, and individual differences, among other factors.

At this point, we would like to sketch out some new orientations for research in this area that may help advance the discussion on the role of attention in SLA.[1] We have pointed out in this paper that although there is evidence from cognitive psychology that detection and learning can take place in the absence of awareness, this has yet to be demonstrated in the context of SLA. Thus, a question that research on attention and SLA needs to address is to what extent such findings from psychology are generalizable to adult SLA. Will

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we observe similar results if the stimuli used in these studies, such as light sequences (e.g., Lewicki et al., 1987), artificial grammar strings (e.g., Carr & Curran, 1994; Reber, 1967, 1976, 1989, 1993), and L1 lexical items (e.g., Marcel, 1983), were replaced with stimuli that involves L2 input? For example, we pointed out earlier that lexical priming studies such as Marcel cannot be used as evidence that detection of L2 input can occur in the absence of awareness, because the task involved the processing of familiar L1 lexical items. Such a study cannot address the question of whether L2 learners can make some kind of L2 form-meaning connection in the absence of awareness (VanPatten, 1994). This question, however, could be empirically tested with an experiment that exposed L2 learners to some kind of L2 input that allows for new form-meaning connections to be made below the threshold of awareness. If we find that subjects who detected this stimuli below the threshold of awareness (i.e., those who were not aware) perform better on some kind of performance measure than those who were not exposed to the stimuli, and perform as well as subjects who were exposed to the stimuli above the threshold of awareness (i.e., those who were aware), then we will have more concrete evidence that awareness is not necessary for detection of L2 input. However, if we find that subjects who were exposed to the L2 input below the threshold of awareness do not perform better than those subjects who were not exposed to the input at all, then there is a problem with the position that awareness is not necessary for detection and learning to occur in an L2 context.

It is noteworthy to mention that one SLA study, Robinson (1996a, 1996b), did set out to address the generalizability of Reber's (1989, 1993) findings from artificial grammar studies to the context of adult SLA. According to Reber, implicit learning is more effective than explicit learning when the stimulus domain is complex, and explicit learning of simple and complex stimulus domains is possible when the underlying rules are made salient (Robinson, 1996b, p. 27). Robinson replicated Reber's research design with L2 input as the stimulus. As in Reber's studies, subjects were randomly assigned to either implicit, incidental, rule-search, or instructed computerized training conditions. Results showed that implicit learners did not outperform other learners on complex rules as predicted, but the instructed learners performed significantly better than all other conditions in learning the simple rules. Thus, the results of this replication study with L2 input did not fully validate Reber's claims. This finding accentuates the importance of testing the generalizability of psychology studies to the context of SLA. Until we have more studies that address this generalizability issue, we cannot hope to make any substantial claims regarding the role of attention and awareness in SLA.

Another area that research on attention needs to explore in greater depth is how various degrees of attention and awareness may affect SLA. Though it is difficult to operationalize attention and awareness as all-or-nothing entities, it is possible to design conditions and tasks that will engage different levels of learners' attention and awareness (e.g., Hauser, 1999; Leow, 1997; Robinson, 1996a, 1996b; Rosa & O'Neill, 1999).[2] In other words, instead of asking whether

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attention and awareness are necessary or not for SLA, it may be more fruitful for research to examine how different levels of attention and awareness may impact learning. Do different degrees of attention and awareness lead to more learning, less learning, or no difference in learning at all? This direction of research is not only more feasible for the context of SLA, it may also better reflect the nature of the operation of attentional functions as discussed in earlier sections of this paper.

Finally, as pointed out previously, research on the role of attention in SLA needs to view the nature of the task, the nature of the linguistic item, and learner differences as independent variables that have a direct impact on how and to what degree attentional functions and awareness are activated and maintained. In other words, we need to move from merely asking whether awareness is necessary or unnecessary for SLA to addressing a set of finer grained questions. These questions include: How much attention and awareness is necessary for the detection of X, if at all? Is the same amount of attention and awareness necessary when the linguistic item is Y? How much attention and awareness is necessary to detect X (if at all) when the task demand is A? And if the task demand were B? Could an individual difference variable, such as processing or working memory capacity, constrain the amount and type of L2 input a learner can pay attention to (see Sagarra, 2000)?

As more research in this area moves toward addressing these questions, we should have a deeper understanding of the nature of attentional functions and awareness in SLA. We hope the criticisms raised in this paper and the research orientations proposed can serve as a stepping stone for theory building and for empirical research on the role of attention in SLA.

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NOTES

1. We would like to acknowledge two anonymous *SSLA* reviewers for suggesting that we include a section on new orientations for research. Though it is not within the scope of this paper to outline detailed research designs, we have highlighted some research questions for future studies to address.

2. As discussed earlier in this paper and noted by one anonymous *SSLA* reviewer, it could be argued that Leow's (1998) study did in fact look at degrees of orientation. One can argue that learners in Group 3 were relatively more oriented than the other groups, but one cannot say that there was no degree of orientation at all on the other puzzles.

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