FOCUSED TASKS, MENTAL ACTIONS AND SECOND LANGUAGE LEARNING. COGNITIVE AND CONNECTIONIST ACCOUNTS OF TASK EFFECTIVENESS

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ABSTRACT

This paper presents a theoretical framework to estimate the effectiveness of second language tasks in which the focus is on the acquisition of new linguistic items, such as vocabulary or grammar, the so-called focused tasks (R. Ellis, 2003). What accounts for the learning impact of focused tasks? We shall argue that the task-based approach (e.g. Skehan, 1998, Robinson, 2001) does not provide an in-depth account of how cognitive processes, elicited by a task, foster the acquisition of new linguistic elements. We shall then review the typologies of cognitive processes derived from research on learning strategies (Chamot & O'Malley, 1994), from the involvement load hypothesis (Laufer & Hulstijn, 2001), from the depth of processing hypothesis (Craik & Lockhart, 1972) and from connectionism (e.g Broeder & Plunkett, 1997; N. Ellis, 2003). The combined insights of these typologies form the basis of the multi-feature hypothesis, which predicts that retention and ease of activation of new linguistic items are improved by mental actions which involve a wide variety of different features, simultaneously and frequently. A number of implications for future research shall be discussed.

Introduction

The goal of second language education is that learners become fluent second language users. To achieve this, it is important, among other things, to store new linguistic information in such a way that it can be accessed quickly when needed. How can tasks support the storage of and access to language? In this paper, we take a cognitive perspective on second language learning, which emphasizes the role of mental actions in the acquisition of new linguistic items (Baddeley, 1997; N. Ellis, 2001). Tasks can be used to elicit these mental actions (Driessen, Haenen & Westhoff, 2002). A central question in this article is: how can we use information about the learning impact of mental actions to determine the learning impact of tasks? In order to address this question, we shall first consider cognitive accounts of the mechanisms by which mental activity influences second language acquisition. Then, we shall review a number of typologies of tasks and mental actions, focusing on their underlying theoretical accounts of the learning impact of different types of processing. We shall start with the frameworks for task analysis designed by proponents of the task-based approach to language learning (e.g. Skehan, 1998; Robinson, 2001). Although valuable, we argue that these frameworks do not offer in-depth theoretical accounts regarding the differential effects of different types of mental actions elicited by focused tasks, i.e. tasks in which the focus is on the acquisition of new linguistic items, such as vocabulary or grammar (R. Ellis, 2003). We shall then review the typologies derived from research on learning strategies (Chamot & O'Malley, 1994), from the involvement load hypothesis (Laufer & Hulstijn, 2001), from the depth of processing hypothesis (Craik & Lockhart, 1972) and from connectionism (e.g Broeder & Plunkett, 1997; N. Ellis, 2003). The combined insights of these typologies form the basis of the multi-feature hypothesis (Westhoff, 2004), which offers a framework for the analysis of focused tasks in terms of the differential effects of different types of mental actions elicited by tasks.

A cognitive perspective on SLA: the concept of mental actions

In this paper, we take a cognitive perspective on second language acquisition. More specifically, we focus on the cognitive processes that promote storage of and access to linguistic knowledge. Findings from cognitive psychology (e.g. Anderson, 2000; Baddeley, 1997) shed some light on the mechanisms of human information processing. Human memory consists of sensory memory, working memory and long-term memory. Different models of memory (e.g. Baddeley, 2003; Cowan, 2005; Gazzaniga, Ivry & Mangun, 2002) agree on the general distinction between these three types of memory, but differ in such aspects as the relationship between sensory memory and working memory, and the components of working memory itself (e.g. Cowan, 2005). However, these distinctions do not affect the general model (N. Ellis, 2001), which forms the basis of the theoretical framework presented in this paper.

New incoming information, e.g. visual or auditory input, is first registered in sensory memory and then further processed in working memory. Baddeley (2003) describes how in working memory information is temporarily maintained, manipulated and combined with information from long term memory. These processes result in the formation of links between the new information and long-term memory (Cowan, 2005). Processing of information in working memory leaves memory traces in long-term memory and different types of processing result in different traces (Lockhart & Craik, 1990). These traces allow an item, concept or structure to be activated or recalled when it is needed. Thus, learning is the result of mental activity in working memory, such as selecting, combining and interpreting. The concept of active, mental construction of knowledge by the learner has also been stressed in cognitive approaches to second language acquisition (N. Ellis, 2001; Schmidt, 2001) and in sociocultural and cognitive educational psychology (Arievitch & Haenen, 2005; Bransford, Brown & Cocking, 2000).

In current teaching practice, second language learning tasks are used to engage learners in different types of processing. In order to maximize the effectiveness of tasks, it is useful to know what accounts for the learning impact of these different types of processing. Before we review the literature, it is necessary to specify what we refer to when we use the term task and how we conceptualize the relationship between tasks and mental processes. In the field of second language acquisition, there is not one generally accepted definition of a task (see for an overview Bygate, Skehan & Swain, 2001; R. Ellis, 2003). For example, the definition by Breen (1987) includes all classroom activities directed at language learning, such as practice exercises, communication tasks and language tests. According to Willis (1996), on the other hand, a task is a goal-oriented and communicative activity in which the learners are free to choose their own linguistic resources. Skehan (1998) presents an extensive definition, which includes, among other things, that tasks should be meaningful, related to real-world activities, and that tasks should be assessed according to their outcome. Ellis (2003: 3) defines tasks in a more general way as “activities that call for primarily meaning-focused language use”. There are of course many more definitions, but an extensive review would be beyond the scope of this paper. In order to categorize these definitions, Littlewood (2004) proposes a continuum between an exclusive focus on forms on the one hand, and focus on meaning on the other. Non-communicative learning activities (e.g. decontextualized grammar drills) are at the focus on forms end. At the other end, in which the focus is on meaning, are authentic communication tasks. The stages in the middle, i.e. pre-communicative, communicative language practice and structured communication, include tasks or activities which gradually focus on form(s) as well as meaning and which are progressively less pre-structured by the teacher.

From the cognitive perspective outlined above, the conclusion is that learners have to engage in some type of processing in order to acquire the second language. The only thing that we can be sure about is that, in the real world, language use always entails meaning. For this reason, we adopt the general definition of a task by Ellis (2003: 3), according to which tasks are “activities that call for primarily meaning-focused language use”. From our perspective, these activities include all the activities placed on Littlewood’s continuum (2004), except for those that

focus exclusively on forms. In order to conceptualize the relationship between tasks, as defined above, and mental actions, we shall use the framework proposed by Driessen, Haenen and Westhoff (2002). They distinguish between three constituents of a task: the assignment, the elicited mental actions and the content. It is the assignment of tasks that elicits mental actions. These mental actions involve a specific content. Learners always process something and, generally speaking, in second language learning tasks, the content is meaningful language. For example, the assignment to choose a number of useful school subjects for a specific profession, elicits a mental action such as categorizing. The school subjects are the content at which the mental actions are directed. The learner must process different aspects of the content in order to be able to categorize, for example meaning, use, and frequent co-occurrence with other concepts. Taken together, assignment, elicited mental actions and content can be expected to play a role in predicting the potential effectiveness of a task.

Now that we have specified the types of tasks we refer to in this paper, we shall review a number of approaches that have sought to account for the effect of different types of processing elicited by tasks on second language learning. We shall first focus on the theoretical positions taken in the literature on task-based language education.

The place of mental actions in the task-based approach

Just as there are various definitions of tasks, the task-based approach to second language learning is not a uniform approach. A number of characteristics of the task-based approach can be summarized, though. Tasks are considered the central unit of instruction and the main source of input in the classroom (Richards & Rodgers, 2001; Swan, 2005) and are supposed to trigger "natural acquisitional mechanisms" (Skehan, 1998: 95). Swan (2005) argued that the psycholinguistic rationale for task-based instruction is generally associated with three hypotheses: an on-line hypothesis (Schmidt, 2001; Doughty, 2001), the noticing hypothesis (Schmidt, 2001) and the teachability hypothesis (Pienemann, 1998). From these hypotheses, it follows that second language acquisition takes place in the course of interaction and communication, that learners must consciously notice salient features in the input in order to be able to acquire them, and that learners follow a determined developmental path.

Willis (1996) describes six task types, which elicit different types of processing. Listening tasks might involve brainstorming or fact-finding. Tasks directed at ordering and sorting include sequencing items in a specific order, ranking items according to specific criteria, categorizing items in given groups and classifying items without previously given groups. Tasks which involve comparing trigger processes such as matching and finding similarities and differences. Problem-solving tasks can elicit different types of reasoning. Tasks directed at sharing personal experiences elicit interaction on social and personal topics. Creative tasks are large-scale projects which involve free or creative language use. Although Willis (1996) lists a number of mental actions that can be elicited by tasks, such as sequencing, ranking and comparing, she

does not provide any theoretical account of how these processes might foster the acquisition of new linguistic elements.

Nunan (2004) distinguishes between six components of a task: goal, input, procedures, learner role, teacher role and settings. He defines procedures as: "what learners will actually do with the input that forms the point of departure for the learning task" (2004: 52). According to Nunan, there are three ways in which these processes can be analyzed. First, he refers to the concept of procedural authenticity, to indicate that some processes elicited by the task resemble more closely real life activities than others. Second, some processes are directed at skill getting, whereas others are directed at skill using. The third way of analyzing learner processes is concerned with the development of fluency or accuracy. Despite his useful distinction of procedures as a task component, Nunan does not provide an account of the differential effects of different types of procedures.

R. Ellis (2003) enumerates six critical features of a task: a task is a work plan, which involves a primary focus on meaning, real-world processes of language use and any of the four language skills. A task should also elicit cognitive processes and have a communicative outcome. With regard to the cognitive processes elicited by the task, R. Ellis (2003) points out that a task should engage learners in cognitive processes, such as classifying, ordering and evaluating. Despite this emphasis on the cognitive processes elicited by tasks, R. Ellis (2003) does not provide any theoretical account which allows us to estimate the effectiveness of different cognitive processes in terms of second language acquisition.

In a review article on task-based instruction, Skehan (2003) describes the cognitive approach to tasks, which studies the allocation of attentional resources during task performance and the effect of task characteristics and conditions on performance. Robinson (2005) makes a further distinction between the effects of tasks on second language performance and development. The models proposed by Skehan (1998) and Robinson (2001, 2005) share similarities, but differ in their predictions with respect to the effect of tasks on the fluency, accuracy and complexity of performance, and on the allocation of attentional resources. Although a full comparison and discussion of the two models is beyond the scope of this paper, we shall briefly consider both models here and focus on their theoretical accounts of the effectiveness of mental actions elicited by tasks.

Skehan (1998) argued that tasks can selectively channel attention to fluency, accuracy and complexity of language use. This can be achieved by manipulating specific dimensions in the design and selection of tasks. He distinguishes between three task dimensions: "language required", "thinking required" and "performance conditions" (p. 99). The language required is labeled code complexity and comprises linguistic complexity and variety, vocabulary load and variety, and redundancy and density. The thinking required is labeled cognitive complexity and is broken down into two categories: cognitive familiarity and cognitive processing. The difference between cognitive familiarity and cognitive processing seems to be whether the declarative

knowledge necessary to perform a task is readily available to the learner as a familiar chunk or whether the task requires substantial computation. Cognitive familiarity comprises topic familiarity and predictability, which relate to background knowledge and the learners' familiarity with the macrostructure of the task types. Cognitive processing is the processing load during task performance. Skehan mentions the following elements of cognitive processing: organization of task-relevant information, amount of computation, clarity and sufficiency of information, and type of information. However, if we distinguish between cognitive processes and the content of these processes, it is unclear where these elements fit in. Organization of task-relevant information and amount of computation seem to refer more to processing itself, whereas clarity, sufficiency and type of information seem to be related to the object that is processed. At one point Skehan analyzes the relationship between type of processing and the content that is processed. He points out that amount of computation might elicit the use of many items simultaneously or the use of if/ then statements. However, this isolated reference does not allow us to predict the effect of a specific type of processing. The third element of Skehan's task dimensions is performance conditions. These entail different types of communicative stress, such as time limits and pressure, speed of presentation, number of participants, length of text used, type of response required and opportunities to control the interaction. These factors influence processing and might direct attention to fluency, accuracy or complexity.
Skehan's model of task dimensions is aimed at predicting which tasks direct the learners' attention to aspects of fluency, accuracy and complexity. As such, it is a valuable model for unfocused tasks. It might not be suitable for the analysis of focused tasks, however. At various point in his book, Skehan (1998) makes clear that the acquisition of new linguistic elements is not the primary focus of the type of tasks he proposes. We argue therefore, that Skehan's model does not provide a theoretical account with regard to the mental actions elicited by focused tasks.

Robinson (2001, 2005) proposes a triadic componential framework for investigating task effects on SLA. The framework consists of three factors which, taken together, influence second language acquisition: task complexity, task conditions and task difficulty. The first factor, task complexity, consists of two dimensions: resource-directing and resource-dispersing factors. Increasing task complexity along the dimension of resource-directing factors increases the task's conceptual demands. Because the L2 encodes these conceptual demands, this will result in an increase of the linguistic demands on the L2 user. This type of increasing task complexity is hypothesized to result in interlanguage development. Examples of resource-directing factors are the number of elements to be described or references to the here-and-now versus the there-and-then. Increasing task complexity along the dimension of resource-dispersing factors means gradually removing task elements that support processing, such as planning time or access to prior knowledge, or adding extra elements, such as dual tasks, in order to increase practice of access to and use of interlanguage knowledge during performance. As such, an increase in the dimension of resource-dispersing factors is also hypothesized to foster second language performance. The second factor, task conditions, can be broken down into two parts: participation and participant variables. Participation variables refer to the types of participation

required, such as one-way or two-way tasks, or open versus closed tasks. Participant variables refer to the relationships between the participants, for example gender and power. The third factor, task difficulty, comprises learner factors that influence the perception of task difficulty by the individual learner, such as ability and affection. Robinson's cognition hypothesis (2005) predicts that increased cognitive task complexity will lead to an increase in interactive and cognitive processes, which will result in positive effects on performance and development. Increases in task complexity are hypothesized to lead to: a. more accuracy and complexity of performance; b. more interaction, negotiation of meaning and elaborative processing; c. more attention to, noticing of and incorporation of forms in the input.

Robinson's examples of cognitive processes are attention to input and output, noticing and rehearsal in working memory. Although Robinson's model (2005) includes references to the cognitive processes elicited by tasks, it does not provide detailed accounts of the differential effects of different types of mental actions elicited by tasks.

To conclude, the frameworks for task-analysis reviewed above all refer to the mental actions the learners are involved in during task performance, for example, matching, comparing and reasoning (Willis, 1996), comprehending and manipulating (Nunan, 2004), classifying, ordering and evaluating (R. Ellis, 2003), amount of computation required (Skehan, 1998) and attention and noticing (Robinson, 2005). This means that proponents of the task-based approach agree on the central place of mental activity in second language learning. However, these frameworks do not provide clear accounts of the underlying mechanisms that relate these types of processing to the acquisition of new linguistic elements. It is unclear why and how these mental processes, for example matching or classifying, effectively result in the acquisition of new linguistic elements. Moreover, these frameworks do not allow us to estimate the differential effectiveness of different types of processing elicited by a task. Should a student who wants to acquire new vocabulary or grammar, choose a task which involves classifying and ordering or rather a task which involves matching? One of the reasons for this might be that, generally speaking, proponents of the task-based approach are not primarily concerned with tasks that focus on the acquisition of new linguistic elements (Swan, 2005). One of the key criteria of a task is that learners are free to choose their own linguistic resources (Willis, 1996; Skehan, 2003). This means that the research agenda has focused on the effects of task characteristics on performance factors such as fluency, accuracy and complexity (Skehan, 2001; Robinson, 2005). An exception is Robinson's framework (2005), which predicts that an increase in cognitive demands will result in, among other things, attention to and subsequent incorporation of forms in the input.

To sum up, the task-based approach does not provide in-depth theoretical accounts of the learning impact of different types of processing. However, in order to analyze the effectiveness of a task, it is necessary to determine the learning impact of mental actions elicited by a task. In the remainder of this paper, we shall consider a number of theoretical approaches that might help us to further explore this area. In the next section, we shall turn to some examples of

typologies of mental actions for second language learning that were not specifically related to the task-based approach.

Typologies of mental actions for second language learning

Chamot and O'Malley (1994) propose learners a typology of language learning strategies, based on cognitive theories of the active mental processing of new information. The learning strategies are divided into metacognitive strategies, cognitive strategies and social/affective strategies. The cognitive strategies, which, according to Chamot and O'Malley (1994: 375), interact "with the material to be learned by manipulating it mentally or physically" are of most interest to us.

Chamot and O'Malley present eight cognitive learning strategies. Elaboration of prior knowledge entails the linking of new information to prior knowledge via associations or analogies. Making inferences is the strategy in which the linguistic context is used to guess the meaning of words, to complete or to predict information. Linguistic transfer refers to the use of prior linguistic knowledge to support comprehension and production. Grouping means classifying material according to specific features. Imagery is the use of visual information to comprehend or recall new verbal information. Auditory representation means mentally repeating the sound of a word or phrase to support learning. Deduction and induction refer to the application of rules or to inventing rules to understand language. Summarizing is synthezing the information in order to make sure it is retained. This classification of mental actions is based on cognitive theories of actively manipulating information in working memory. As such, it is a more detailed account of the mental actions that foster second language learning than those provided by proponents of the task-based approach. However, the typology by Chamot and O'Malley (1994) does not provide a theoretical account of differences in learning impact of different learning strategies. Is there, for example, a difference in learning impact between elaborating, using imagery and grouping? On what theoretical grounds can the differences (or similarities) in learning impact of these mental actions be established?

Laufer and Hulstijn (2001) propose the involvement load hypothesis, which aims at the operationalization of different types of mental actions: elaborate processing (Anderson, 2000; Craik & Lockhart, 1972) and attention (Schmidt, 2001). The hypothesis is explicitly directed at incidental vocabulary acquisition as a result of task performance. The amount of involvement is determined by the factors need, search, and evaluation. Need is the motivational, non-cognitive part of the involvement load and refers to the motivation to complete the task. Moderate need is externally imposed, for example by the teacher, while a strong need is the learner's own motivation to complete the tasks. Search' and 'evaluation are the cognitive components of the involvement load. 'Search' is the search for the meaning of an L2 word in the L1, or the search for the L1 word which translates the L2 word, for example by using a dictionary or asking the teacher. Search can either be present or absent during task performance. Evaluation can mean:

a. to compare the meaning of a specific word with other words or recognizing the differences between words; b. to compare a specific meaning of a word with its other meanings; c. to assess whether a word fits in a specific context.

The first two types of evaluation are moderate, while the third is strong. It is expected that tasks which elicit a higher involvement load yield better retention of vocabulary than tasks with a lower involvement load (for empirical evidence, see Hulstijn & Laufer, 2001). Laufer and Hulstijn (2001) present the concept of task-induced involvement as an initial attempt to operationalize different types of processing in incidental vocabulary tasks. As such, it is a valuable contribution to the study of incidental vocabulary acquisition. However, a number of issues remain unclear. What mechanisms account for the superior effectiveness of, say, strong evaluation, as opposed to moderate evaluation? The factors search and evaluation both seem to imply some form of cognitive comparison. What about other types of processing, for example those mentioned by Chamot and O'Malley (1994)? It is unclear whether the concept of involvement load can be applied to determine the differential effects of these mental actions. The involvement load hypothesis is aimed at predicting which mental actions yield better retention of vocabulary. What about the effects of mental actions on real time language use? The concept of involvement load does not seem to predict whether differences in involvement result in differences with respect to ease of activation of the vocabulary items.

In order to take a closer look at the learning impact of cognitive processes, we shall now turn to a number of papers from cognitive psychology, more specifically those on the depth of processing hypothesis by Craik and Lockhart (1972). These papers introduce two aspects that have received little attention in the papers reviewed above: the importance of the characteristics of the content that is processed, and the differential effects of processing on retention and recall.

Typologies of mental actions from cognitive psychology

Craik and Lockhart (1972) propose the levels of processing framework, in which memory is conceived of as the byproduct of mental activity. New incoming input proceeds through a series of processing stages, and at each stage the input is being analyzed for a different feature type. The first stages of input analysis involve physical and sensory features and pattern recognition. At a later stage, semantic features are analyzed. This analysis results in a memory trace of the input, which allows the processed material to be remembered. A deeper level of analysis, i.e. analysis of the input not only at the first sensory stages but also at the later semantic stages, will result in more durable memory traces. Thus, depth is operationalized as processing semantic and conceptual features of the input, whereas shallow refers to the processing of sensory features, such as orthographic or phonological characteristics of the words. Besides the concept of depth, Craik and Lockhart (1972) introduced the concept of elaborateness. They distinguished between two types of rehearsal. Maintenance rehearsal is rote repetition

or the rehearsal of an item at the same depth. Elaborative rehearsal involves processing at deeper levels. It was hypothesized that only elaborative rehearsal leads to long term retention. In a subsequent article, Craik and Tulving (1975) presented a number of experiments on the depth of processing hypothesis. Subjects were induced to process words in a specific way by answering different types of questions about the target words. Processing at shallow levels was induced by asking questions about structural and phonemic aspects of a word. Deeper levels of processing were induced by questions about the category a word might belong to and by asking whether a word fits into a particular sentence. Both recall and recognition of the target words were tested. The results show that a deeper level of processing, as defined by answering meaningful questions, result in higher scores on both recall and recognition tests than shallower levels of processing.

In 1990, Lockhart and Craik (1990) presented a retrospective review of the depth of processing hypothesis, in which they discussed a number of conceptual changes and refinements of their initial hypothesis. First of all, they indicated that processing does not necessarily proceed in a serial fashion of different stages, it can also be parallel. Second, Lockhart and Craik made clear that their original distinction between shallow sensory or perceptual processing and deep conceptual or semantic processing is not limited to linguistic information only. This distinction can also be applied to other domains or modalities, such as vision or taste. They also provided a further explication of the concepts of depth, elaboration and distinctiveness. Depth refers to "qualitatively different types of processing" (p. 100), such as the shallow processing of structural aspects of words or the deep processing of their meaning. Elaboration is the richness or extensiveness of processing within one level. The distinctiveness of a memory trace determines whether it is easily distinguishable from other traces. Because richly elaborated memory traces are more redundant and distinctive than impoverished traces, they yield better recall and recognition. Lockhart and Craik (1990) concluded that, although their original formulation of the depth of processing hypothesis had changed considerably, the influence of different types of processing on memory is now widely accepted.

Brown and Craik (2000) discuss a number of factors that contribute to the successful acquisition of new information. Besides pointing at important factors such as the goal of the learner, prior knowledge and type of material to be learned, they also refer to the importance of the qualitative nature of the processing operations applied. In their words, "paying attention is not an end in itself" (p. 96). Brown and Craik further refer to the levels of processing framework and state that processing at a semantic or conceptual level leads to better retention than processing at sensory levels. Elaborative rehearsal is more effective than maintenance repetition. With regard to the content that is processed, Brown and Craik point out that it is important to process features that allow a concept, word or chunk of information to be retrieved more easily. They distinguish between item-specific features, which are unique for a specific concept, and associative features, which are features shared with information from prior knowledge or information simultaneously present. Processing both types of features will improve memory of the target words or concepts.

The concepts of elaborative rehearsal and the processing of features are also stressed by Anderson (2000). He points out that the way in which the study material is processed determines whether something is remembered or not. He refers to this as 'elaborative processing', which he defines as "embellishing a to-be-remembered item with additional information" (p 190). This should result in better memory, because the elaborations constrain the to-be-remembered item.

To conclude, findings from cognitive psychology support the notion that the type of processing the subjects are engaged in influences retention and recall of information. Craik and Lockhart (1972), Craik and Tulving (1975), Baddeley (1997) and Anderson (2000) all argue that meaningful, conceptual or semantic processing leads to enhanced memory performance, as opposed to sensory or perceptual processing. Furthermore, mental actions that yield elaborate memory traces are more effective. Because richly elaborated memory traces are more redundant and distinctive than impoverished traces, they yield better recall and recognition. However, a number of questions remain. What constitutes an elaborate memory trace? What accounts for the relation between memory traces and ease of activation? What type of mental actions yield memory traces that can be easily activated in real time language use? In order to explore these questions, we shall now consider the literature on connectionist models of second language acquisition.

Mental actions in connectionism

Above, we have described how mental actions operate in working memory, and how these activities leave traces in long-term memory. According to recent neurological research, knowledge is represented in the human brain as a pattern or network of neurons (e.g. Anderson, 2000; Gazzaniga, Ivry & Mangun, 2002; Markowitsch, 2000). The concept of knowledge representation as a pattern or network has been expressed in cognitive psychology since the 1970's (e.g. Rumelhart & Ortony, 1977). It is also reflected in the literature on connectionist models of second language acquisition (e.g. Broeder & Plunkett, 1997; N. Ellis, 2003; Gasser 1990). The basic finding is that information, in the form of concepts or knowledge, is not stored as a blueprint. A single neuron cannot encode knowledge. Instead, knowledge is represented by a pattern of neural activity. This pattern is temporary. What is stored, are the connections among the neurons that allow a pattern to be reproduced or re-created. These connections are the so-called memory traces. It is a pattern of neural activity over a large amount of neurons, i.e. a memory trace or connection, that allows these concepts to be reproduced. A characteristic of this pattern of neural activity is distributed representation (Anderson, 2000; McClelland, 2000). Each neuron or pattern of neurons can participate in the representation of many different concepts. In cognitive psychology, this phenomenon of levels is present in schemas (Baddeley, 1997). Schemas represent our world knowledge and personal experience at different levels. Connectionist models can include information at all different levels (McClelland, Rumelhart & Hinton, 1986).

Different labels are used in the literature to refer to these networks and the elements that constitute them. Cognitive psychology speaks of patterns of neural activation over an amount of neurons (Anderson, 2000). Connectionism refers to networks which consist of connections among units, roughly comparable to neurons (Bechtel & Abrahamsen, 2000; Bereiter, 1991; Broeder & Plunkett, 1997; Gasser, 1990). In this paper, we will use the terms network and unit when we refer to the connectionist theoretical framework. We suggest the term 'feature' for a specific connection among units or, in cognitive terminology, a specific pattern of neural activation over an amount of neurons (Westhoff, 2004). It is this connection between neutral neurons that constitutes meaning such as a grammatical structure or vocabulary item. The term feature has also been used e.g. by Baddeley (1997), Levelt (1989) and Gasser (1990).

Before we review the literature on the activation of these networks, it is necessary to specify the elements that constitute a network. By way of example, we shall consider the features of a vocabulary network. Descriptive frameworks of different aspects of vocabulary knowledge have been proposed by Richards (1976), Laufer (1997), and Nation (1990, 2001). A more explanatory framework about aspects of word knowledge related to the mental lexicon is offered by Levelt (1989). Taken together, there seems to be consensus on at least the following aspects of vocabulary knowledge: form (pronunciation and spelling), meaning, collocations, morphology, syntactic behavior, constraints on use (register, frequency, pragmatic) and affective features. However, according to Aitchison (1994), knowledge of a word or concept is broader than aspects that, strictly speaking, belong to the category of linguistic meaning. Examples of other aspects of word knowledge are sensory aspects (Westhoff, 2004), information from the non-linguistic context (Croft & Cruse, 2004) and emotions (Bereiter, 1991). Broeder & Plunkett (1997) stress the diffuse and interactive nature of a variety of different units implied in the processing and acquisition of concepts and language. In connectionist models, all these different types of units interact simultaneously to represent a specific concept.

Processing, acquisition, representation and activation are closely related in connectionist models (McClelland, Rumelhart & Hinton, 1986). This leads to a number of claims regarding how new information should be processed in order to increase its retention and ease of subsequent activation.

Claim 1: Networks that consist of many different types of features have more chances of becoming activated.

We have already described that knowledge is represented in long-term memory in the form of patterns of neural activity. When a network is activated, this means that it is made available to working memory (Anderson, 2000). Neurons interact with each other to form a pattern and determine each other's level of activation. Excitation is the process by which neurons increase the activation level of other neurons. Inhibition occurs when neurons decrease the activation of other neurons. A network can be activated by receiving new sensory input from outside, or through a stimulus from within the learner (Rumelhart, 1989). In the previous section, we

described that a feature network consists of many different types of features, for example morphological, sensory or pragmatic. The network can be activated through each of the feature types that constitute it. The stimulus that causes the activation can have different modalities, e.g. visual, auditory, and emotional (N. Ellis, 2001). Therefore, it can be concluded that networks that consist of many different features have more chances of becoming activated. This is an important argument for designing tasks which involve a wide variety of content features.

Claim 2: The strength of the connections among the features will be increased by processing features simultaneously in working memory. Strong connections result in a quick spread of activation. A network with such connections will be activated more easily.

Features activate each other. This principle is called spreading activation (Anderson, 2000; (McClelland, Rumelhart & Hinton, 1986). Activation spreads along the features or connections of a network. It spreads from information activated in working memory to networks that are connected to that information, and so become activated as well. The speed of the spreading activation is determined by the strength of the connections. Activation will spread more quickly through networks with strongly interconnected units. Connection strengths are enforced by processing features simultaneously in memory (Broeder & Plunkett, 1997; N. Ellis, 2001; Gasser, 1990). Strong connections allow a concept or structure to be 're-created', or activated faster and more easily.

Claim 3: Frequency of use increases connection strength and networks with strong connections will be activated more easily.

The speed at which a feature network can be made available to working memory is determined by its level of activation. This is not a permanent state. Two factors influence level of activation: recency and frequency of use. Networks that have been activated recently can be activated more easily once again. Frequency of use increases the strength of a memory trace or the strength of the connections. A memory trace that is stronger through repeated practice can be activated more quickly (Anderson, 2000). This is an argument for tasks which frequently elicit mental actions on different aspects of the content.

To sum up, a number of factors determine the speed of activation of feature networks. A rich feature network, which consists of a variety of features, can be activated more easily. Features that are processed simultaneously in working memory will be more closely interrelated and will activate each other more quickly. Networks that are used frequently can also be activated faster. We predict that tasks that elicit mental actions as specified by the three above-mentioned claims will have a more positive effect on retention and ease of activation of new language. This claim is elaborated in the multi-feature hypothesis, which we describe below.

The multi-feature hypothesis

The multi-feature hypothesis is based on the cognitive and connectionist theoretical framework presented in this paper. It translates insights from cognitive psychology and connectionism into guidelines for the analysis and design of focused tasks. It is expected that retention and ease of activation of new language are enhanced by tasks that elicit mental actions involving:

- more features (of the vocabulary item or language structure),
- more different categories of features,
- in life-like combinations,
- simultaneously and
- in great frequency.

It is predicted that mental actions that involve more, and more different, feature categories will result in networks that consist of many different types of features. Such rich networks are more easily activated than networks that consist of less or less different features. Life-like feature combinations are combinations that most frequently co-occur in the input. Since these occur most frequently, networks that consist of frequent feature combinations will have more chances of becoming activated. Mental actions that involve simultaneous and frequent processing of feature combinations will result in stronger connections in a network. As a result, activation spreads faster and networks will be more easily activated.

How can a task elicit mental actions involving a wide range of frequent feature combinations simultaneously and frequently? To briefly illustrate this, consider the two fragments of think-aloud protocols below. These fragments were taken from a small-scale study on the effects of different tasks on the acquisition of Spanish vocabulary, and illustrate how mental actions can involve more or less different features. The pupils, who are about twelve years old, are from a Dutch secondary school. In the first fragment (left), the learner was given the assignment to write down school subjects in a timetable. The school subjects were given. According to the definition by R. Ellis (2003) this was not a task, because this activity can be performed without knowing what the words mean. The fragment shows that the pupil processes mainly structural features, such as spelling and pronunciation. The second fragment (right) shows the think-aloud protocol of a pupil who is deciding which school subjects are useful for a cab driver. The assignment was to choose useful school subjects for a number of professions.

Table 1: Think-aloud protocols taken from a small-scale study on the effects of tasks on the acquisition of Spanish vocabulary

Fragment 1	Fragment 2
Eh, let's see what's still left, physics, *fi física or* something like that, on *miércoles*, I do physics, *física*, and I do physics once more on *jueves* in any case, *jueve*, what was it like? *Jueves* then I do it from 14 to 15 I do once more physics and then I've got only one left geography, *geografía*, I put that on *jueves* the 15th and 16th hour.	Ethics or geography, geography that is more suitable for a cab driver mathematics no, a cab driver does have to, he's got a meter, mathematics should be there, because they also have to return change they have to be able to count, oh no, now I write it down in Dutch, *matemáticas* or something like that. Geography also belongs to cab driver, or not, I'm not sure anymore *geografía*.

The protocol shows that the mental action in the second fragment involves more features than just spelling and pronunciation. The mental action involves semantic meaning and also activates the pupil's broader schema with regard to cab drivers. The combination of geography and mathematics is a life-like and useful one in view of a cab driver's job description. These fragments show, on a small scale, how assignments can elicit mental actions that involve more or less features, more or less frequently and simultaneously.

Implications for research

The multi-feature hypothesis entails a number of implications for the study of tasks. Research should be directed at establishing whether there are differences in retention and ease of activation between tasks that elicit mental actions on more or less different feature categories. It is predicted that impoverished tasks, which elicit mental actions on only a few features will result in less retention and ease of activation than rich tasks which involve more features. An important prerequisite of any research that attempts to study the differential effects of different types of processing is to establish whether these processes actually take place in the course of task performance. Does a task really elicit mental actions which involve different types of features? We argue that, in this type of research, it is important to focus on both learning processes and learning outcomes. The learning processes during task performance might be studied with think –aloud protocols and retrospective interviews. Assessing learning outcomes, defined as retention and ease of activation of vocabulary and language structures, requires types of tests that measure some form of real time language use. Task-based assessment should be used to measure differences in ease of activation.

Conclusion

In this paper we have argued that proponents of the task-based approach agree on the importance of mental actions during task performance. However, the task-based approach does not seem to provide in-depth theoretical accounts of the learning impact of different types of processing. We have argued that this is particularly so with respect to the acquisition of new linguistic elements. We have presented a connectionist theoretical framework to estimate the effectiveness of focused tasks. According to the multi-feature hypothesis, retention and ease of activation are related to the quality and quantity of mental actions on different features of a new linguistic item. A task should not just elicit these mental actions; they should also be frequent and operate on a wide range of different, life-like feature combinations in a simultaneous way. Research should focus on both learning processes, using think-aloud protocols, and learning outcomes, measured by task-based assessment.

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