Discussion One: 3 articles attached

Prior to beginning this discussion, please read the following required articles:

- "Language Acquisition Socialization: Sociocognitive and Complexity Theory Perspectives"
- "The Learning Brain: Lessons for Education: A Précis"
- "The Cultural-Historical Foundations of the Zone of Proximal Development"
- "Self-Determination, Self-Regulation, and the Brain: Autonomy Improves Performance by Enhancing Neuroaffective Responsiveness to Self-Regulation Failure"
- "Acquisition, Learning, or Development of Language? Skinner's 'Verbal Behavior' Revisited"
- "Linguistic variation and micro-cues in first language acquisition."

Based on your resources this week, choose three areas of language acquisition that you found most interesting and that were unknown to you prior to this week.

In your initial post,

- Explain the theoretical perspectives of each of these chosen areas.
- Apply skeptical inquiry to a brief discussion about why language acquisition is an important area for scholars and educators to understand when developing learning opportunities.
- Apply the concept of language acquisition to your own academic success. Has your own language development affected your success as a student? As an employee? How? Based on the resources and your current knowledge, do you believe you could develop areas of language acquisition, personally, that would be beneficial to you, your loved ones, or your friends?

Your initial post should be at least 500 words in length and thoroughly discuss each of the elements in the prompt.

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# Acquisition, Learning, or Development of Language? Skinner's "Verbal Behavior" Revisited

Susana López Ornat and Pilar Gallo
Complutense University of Madrid

In 1957, Skinner, in his "Verbal Behavior", proposed an explanation on how a language is learned. In 1959, Chomsky strongly argued the non-learnability of language, establishing in the field of developmental psycholinguistics the substitution of the term "learning" for that of "acquisition". Currently, the constructivist models describe language acquisition as a process of ontogenetic, gradual, complex, and adaptive change. This new theoretical framework has been especially useful for rereading Verbal Behavior because it facilitates recovering the Skinnerian learning mechanisms. This can be observed in the recent research trends that recapture reinforcement and imitation (echoic responses), although they are now located in the initial phases of the process and are included in a cognitive dynamic that, by gradually increasing its complexity, can achieve grammar. The new constructivist theoretical framework, by retrieving the functional and referential aspects of language, can also take advantage of the classic Skinnerian proposal about the pragmatic types of verbal behavior, providing it with new meaning.
*Keywords: Language Learnability, Imitation, Reinforcement, Skinner*

En 1957 Skinner, en su obra Conducta Verbal, propuso una explicación sobre cómo se aprende un lenguaje. En 1959 Chomsky argumentó contundentemente la no aprendibilidad del lenguaje instaurando en el ámbito de la psicolingüística evolutiva la sustitución del término aprendizaje por el de adquisición. En la actualidad los modelos constructivistas describen la adquisición del lenguaje como un proceso de cambio ontogenético, gradual, complejo y adaptativo. Este nuevo marco teórico ha resultado especialmente idóneo para la re-lectura de la Conducta Verbal porque permite cierta recuperación de los mecanismos de aprendizaje skinnerianos. Esto se manifiesta en las recientes líneas de investigación que recuperan el refuerzo y la imitación (respuestas ecoicas) aunque localizándolos en las fases iniciales del proceso e incluyéndolos en una dinámica cognitiva que, al aumentar gradualmente su complejidad, puede llegar a obtener una gramática. Además, el nuevo marco teórico constructivista, al recuperar las vertientes funcionales y referenciales del lenguaje, puede aprovechar la clásica propuesta skinneriana sobre los tipos pragmáticos de conducta verbal, dotándola de un nuevo sentido.
*Palabras clave: Aprendibilidad del Lenguaje, Imitación, Reforzamiento, Skinner*

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Correspondence concerning this article should be addressed to Susana López Ornat, Departamento de Psicología Básica II, Facultad de Psicología. Universidad Complutense de Madrid. Campus de Somosaguas. 28223 Madrid (Spain). E-mail: slornat@psi.ucm.es
Translation: Virginia Navascués Howard.

The cognitive system is capable of developing a language by means of a process of change whose most significant milestones are found in the first years of life. The Skinnerian proposal about how this system interacts with the linguistic and extralinguistic experience to *learn* a language appears in Skinner's (1957) *Verbal Behavior*. Due to the fact that it focused exclusively on this experience (as dispenser of the behavior to be imitated and of the appropriate reinforcement program for shaping behavior), it was literally flattened by Chomsky's (1959) critique. The Chomskian model (innatist—not developmental-formalist) proposes to explain the *acquisition* of language, reducing to the bare minimum the role of experience. Sixty years after the development of cognitive psychology, the knowledge accumulated about the mind's functioning is stimulating psycholinguists to relocate the topic in question to a more psychological area. This relocation can be specified in the following question: *Why does a child acquire, and not learn, a language?*

The term *acquisition* is in consonance with the Chomskian model. In this work, we propose to analyze what this model is based on and how the current theoretical perspectives (grouped under the general name of "constructivism") offer a rigorous alternative, and can also integrate some aspects noted in Skinner's *Verbal Behavior* in a new framework.

In the first place, constructivism conceives the development of language as a process of change that takes place during ontogenesis. This proposal differs from the Chomskian representational-grammatical innatism, although it does not discard other types of innatism (structural or chronotopic). This constructivist notion can recover the fact that Skinner's arguments never exceed the framework of the child's interaction with the environment. As we now know, this framework is prior to birth.

In the second place, constructivism conceives the development of language as a global process. The complexities of language are not resolved, but are instead gradually built. The basic Skinnerian mechanisms of learning, reinforcement and imitation, are being retrieved as necessary to account for the initial phases of this development. But constructivism exceeds the Skinnerian model many times over because the latter does not explain the emergence of grammatical complexity.

In the third place, constructivism conceives the development of language as a process of adaptive change. Skinnerian verbal behavior proposes contingency relations (referential in the *tacts*, pragmatic in the *mands*) with experience. This viewpoint can be recovered in the new theoretical framework because, contrary to the Chomskian model, it contemplates the development of grammatical knowledge—absent in Skinner—as a huge adaptive success of the process of linguistic development.

The use of the term language "acquisition" is generalized in the field of psycholinguistics and refers to the process of cognitive change, of vital importance to children, which takes place in the first years of life and culminates in the mastery of the grammar of their language. But why does a child "acquire" and not "learn" a language? In order to answer this question, we must go back to Skinner's work (*Verbal Behavior*, 1957) and the critique of this work by Chomsky (*Review of B. F. Skinner's Verbal Behavior*, 1959). Skinner was interested in the behavioral aspect of language. Chomsky was interested in the origin of the grammatical knowledge that organizes it.

Thus, in *Verbal Behavior*, Skinner described language as a behavior that, as such, is learned: "A child learns verbal behavior when utterances relatively lacking in pattern, and which are selectively reinforced, gradually take on forms that produce the appropriate consequences in a given verbal community" (Skinner, 1957, p. 40).

Chomsky's criticism of this work led research to focus on the origin of the grammatical knowledge that a child begins to exhibit from the age of 30 months. But, for this purpose, Chomsky assumed that language is unlearnable. He argued (Chomsky, 1959, 1995), that language was not learnable because:

1. Language is a surprisingly early acquisition that, nevertheless, involves building a complex formal system (grammar). And this is performed by a cognitive system that is still prelogical and preoperative.

2. Language is acquired with no apparent effort.

3. Language is acquired without any explicit instruction, that is, nobody teaches the child to talk.

4. Language is acquired despite "stimulus poverty." Grammatical information is not found explicitly in the stimulus input and, in addition, this input contains informative noise, interruptions, differences between speakers, and is grammatically incomplete.

Chomsky's critique has come to be considered as one of the essential factors in the transition towards cognitive psychology. Its specific influence in developmental psycholinguistics is still evident nowadays, 60 years later, in the generalized adoption of the term "acquisition." This term contains three implicit criticisms of Skinner:

1. Linguistic knowledge can be "learned" because it is predetermined by genetic grammatical knowledge: The acquisition process is guided by the principles of Universal Grammar, transmitted genetically.

2. In any case, linguistic knowledge is the result of a very complex learning process, which Skinner's model does not explain, or explains very scarcely.

3. Grammatical knowledge is the result of specialized learning mechanisms, different from general cognitive mechanisms, and determined genetically in a *specific* way. Language acquisition mechanisms are not general at any point in the process.

Thus, the term "acquisition" began with Chomskian, linguistic roots, and it emphasized the notion that grammar is triggered by the environment rather than learned. Also, grammatical development would be independent of other kinds of developments, linguistic or otherwise: semantic, pragmatic, cognitive.

But this term was maintained in alternative models ("constructivism") to Chomsky's model, as evidence grew revealing that the grammar of a language is learned, but in a very complex way. Evidence showed that it was not sufficient to "land" in a linguistic setting (according to Skinner, a setting that provides the input to be learned and that reinforces progressive approximations to the input) but instead, it was necessary to add internal cognitive dynamics of which no trace is found in behavioral theories.

Currently, recent advances in psycholinguistics and developmental neuroscience (López Ornat, 2003b) allow us to conceive that language is "learned" from a genetic inheritance that is not specifically grammatical, by means of an extremely complex process of self-organized and time-taking change (until adolescence).

The goal of this work is to review Skinner's contributions in the current context, with the aim of rescuing them as basic mechanisms contributing to early language learning. As general mechanisms of cognitive change, which may help explain the first–*pregrammatical*–steps of the acquisition process, without forgetting that the following steps require much more complex theories, capable of accounting for the deep representational changes involved in language acquisition. These more complex theories are currently grouped under labels such as "constructivism," "cognitive-developmental neuroscience," and "emergentism" (Beer, 2000; López Ornat, 1991, 1994, 1996, 1997, 1999, 2001, 2003a, 2003b; Quartz & Sejnowski, 1997). They all respond to the Chomskian challenge to explain the emergence of grammar, but they respond from the assumption of the learnability of grammar during ontogenesis. The most interesting aspect for us now is that, through learnability, we can recover the basic Skinnerian mechanisms of reinforcement and imitation and claim their intervention at the starting point of linguistic development. The novelty is that this learnability, in contrast to Skinnerian learnability, assumes the complexity that this system gradually achieves when it is grammatically formalized.

Another Skinnerian viewpoint that can be recovered by constructivism is the functional approach (Tomasello, 2003) as such: During language development, a formalization process occurs which is performed by a living system that has to adapt and that, by becoming grammatical, is better adapted. The development of grammar is a huge adaptive success.

We will now specify our proposal about some Skinner contributions that are relevant for current theories. We shall do this within the three learnability assumptions: The development of language is a process of change that is: (a) ontogenetic, (b) gradual and complex, and (c) adaptive.

## Language Development as an Ontogenetic Change Process

> A functional analysis of the verbal community is not part of this book, but a few standard problems call for comment. One of them is the old question of the origin of language. Early man was probably not very different from his modern descendants with respect to behavioral processes. If brought in to a current verbal community, he would probably develop elaborate verbal behavior. What was lacking was not any special capacity for speech but certain environmental circumstances (Skinner, 1957, p. 461).

As mentioned, the arguments in favor of the genetic origin of grammar have greatly influenced developmental psycholinguistics. Despite various modifications of these theories, from this perspective, no convincing explanations have been generated to explain issues such as interlingual differences or irregularities. Representational innatism has not been very convincing and it lacks a physiological base. In turn, constructivism accepts architectural innatism—neuron types, cortical layers..., and chronotopy: timing of linguistic maturation (Elman 1993; Elman et al., 1996). It is currently known that, at birth, children have already begun to learn to process linguistic information, limited to prosodic information, which is audible in the uterus during the last three months of pregnancy (Jusczyk, 1997; Lecanuet & Granier-Deferre, 1993), and that they gradually learn to give meaning to the entire linguistic input.

A recoverable aspect of *Verbal Behavior* is that it places explanations, with no hesitancy, in the postnatal period, so that development becomes dependent on experience (Santacruz, 1987). Readers are reminded that in Skinner's and Chomsky's times, until 1995, no one knew that this experience could begin during the 7th month of gestation.

We believe that it is interesting to recover the function of experience because it guides research towards the discovery of the relations between experience and cognitive change (Tomasello, 2000). Nowadays, this is the nucleus of the problem and issues of genetic inheritance are in the periphery. Whatever the genetic inheritance may be, at birth, grammar, language, and verbal behavior are not yet present. How are the first steps taken towards these processes? And how can Skinner's theory contribute to our comprehension of them? These are the questions we focus on in the following sections.

## The Development of Language as a Process of Gradual and Complex Change

> The parent sets up a repertoire of responses by reinforcing many instances of a response. Obviously, a response must appear at least once before it is strengthened by reinforcement. It does not follow, however, that all the complex forms of adult behavior are in the child's unconditioned vocal repertoire. The parent need not wait for the emergence of the final form. Responses of great intricacy can be constructed in the behavior of an organism through a procedure illustrated [...] (Skinner, 1957, p. 29).

> In teaching the young child to talk, the formal specifications upon which reinforcement is contingent are at first greatly relaxed. Any response which vaguely resembles the standard behavior of the community is reinforced. When these begin to appear frequently, a closer approximation is insisted upon. In this manner, very complex verbal forms may be reached. (Skinner, 1957, pp. 29-30).

The above fragments of *Verbal Behavior* show how Skinner accounted for the learning of language. In this explanation, we can emphasize two facets:

1. The gradual conception of language: parents reinforce the *successive approximations* to the adult linguistic model. Skinner thereby proposed that the first productions are far from the model and that, in successive steps, they come closer and closer. He also indicated the essential need for a model. Both issues are current and coherent with the constructivist viewpoint.

2. However, the Skinnerian conception of this learning is linear: "his" learning system is not a system that changes as a result of its activity (Mateo, 2000). Skinner's learning mechanisms cannot change and, therefore, cannot ever induce grammar.

For years, in the field of language acquisition, theories of Chomskian influence (Chomsky, 1959, 1995) proposed that linguistic knowledge develops as a result of the triggering action of the environment and is acquired without errors when the speaker's linguistic competence is activated. Contrariwise, from the constructivist viewpoint, the language-acquisition-system is a complex adaptive system (Bedau, 2003) that is gradually transformed (López Ornat, 1994). Hence, the gradualness of development is valid again today.

Specifically, we suggest that, in order to understand the beginning stages of linguistic development—pregrammatical ones—which are strongly but not exclusively dependent on experience, Skinner-rooted notions are once more taken into account. In fact, we will comment upon some current research trends that reflect and redescribe two of these notions: reinforcement and "imitation."

### *What does gradual mean?*

> The kinds of behavior in which we are usually interested have, as we have seen, an effect upon the environment which has a return effect upon the organism. Such behavior may be distinguished from activities which are primarily concerned with the internal economy of the organism by calling activities which operate upon the environment "operant behavior." Any unit of such behavior is conveniently called "an operant." For most purposes, "operant" is interchangeable with the traditional "response," but the terms permit us to make the distinction between an *instance* of behavior ('So-and-so smoked a cigarette between 2:00 and 2:10 yesterday') and a *kind* of behavior (cigarette smoking). The term "response" is often used for both of these, although it does not carry the second meaning easily. The description of an instance of behavior does not require a description of related variables or of a functional relation. The term operant, on the other hand, is concerned with the prediction and control of a kind of behavior. Although we observe only instances, we are concerned with laws which specify kinds (Skinner, 1957, p. 20).

Skinner distinguished two response levels: the unit, which is a simple response, and the operant response, which is a response category. This distinction can be related to the current differentiation between tokens and types (Plunkett, 1993, 1995). According to the notion of local learning (Lieven, Behrens, Spears, & Tomasello, 2003), both natural and artificial neural networks learn to respond to types from their experience with tokens. This develops into a learning language process that, at first, advances practically item-by-item. A certain language structure (an inflection, an agreement, a syntactic structure) will only be used correctly with/for one or a few words, and not with others. Also, a linguistic production (word or phrase) will only be used correctly at first in/for specific local contexts, and not in generalized ones. In the transition from tokens to types, it is interesting to detect when an utterance switches from being an unanalyzed block to a being framework with interchangeable parts (Lieven, Pine, & Baldwin, 1997; Pine & Lieven, 1997; Smith, Nix, Davey, López-Ornat, & Messer, 2003). For example, at 18 months, a little girl learned the utterance *I want cookies* to subsequently extend it to different objects: *I want crayons, I want Papa,* and *I want Michael.*

However, the gradual increase in complexity does not only affect production or linguistic output. Other recent research trends point out that, throughout the entire development of language, both the input and the learning system become more complex. The system filters the quantity and quality of input it receives as a function of its developmental state (Elman, 1993; López Ornat, 1994) and, in addition, it modifies itself, creating various transition stages (López Ornat, 1996, 1997, 2001, 2003a; Mariscal, 1997, 2001). Thus, children's intermediate grammars have the following characteristics:

1. Concrete: They are made up of rules that do not have the generalization level of adult rules. For example, the subject we studied longitudinally, María, began to produce first-person inflections with action verbs only (Gallo, 1994a).

2. Incorrect: When children's speech undergoes a frequent longitudinal follow-up, grammatical errors are observed. For example, María, when trying to incorporate pronouns in sentences, spent some time producing errors such as: *yo no a camita* [*me not to bed*] (verb omission), *yo sabe* [*me knows*] (agreement), *yo a sentá* [*I to to sit*] (impersonal verb) (Gallo, 1994a).

3. Inconsistent: Within the same observational session, there are correct and incorrect versions of the same linguistic structure. For example: *oto utara, ota utara* [*another + masculine spoon, another + feminine spoon*] (inconsistency in gender agreement: López Ornat, 1996; 2003; Mariscal, 1997; 2001).

Current constructivist models propose a system that starts applying general cognitive processing mechanisms to the linguistic input until it is able to extract some partial grammatical regularity. As children advance in the statistical definition of partial regularities (Hauser, Chomsky, & Fitch, 2002; López Ornat, 1994), the acquired grammatical knowledge, which is partial and simple, permits them to obtain new grammatical knowledge in a way that is—comparatively—independent of experience and more dependent on internal abstraction work (Marcus, 1999; McClelland & Plaut, 1999). From this viewpoint, one could refer to a "learning" process in the first–pregrammatical–phases of linguistic development and, in advanced phases, to "grammatical acquisition."

## General Learning Mechanisms

### *Reinforcement*

For Skinner, parents were very important as reinforcing agents and, therefore, molders of the child's verbal behavior. It was subsequently shown that there are no explicit corrections of grammatical errors (Brown & Hanlon, 1970), that is, parents do not inform their children about whether or not an utterance is grammatical. This was confirmed in the authors' longitudinal study (López Ornat, Gallo, Fernández, & Mariscal, 1994) during which we observed some corrections of articulatory or semantic errors, but only one grammatical correction:

Articulatory correction: Age: 2.00

María: *No se gompe, no se gompe, ¿sabes? [It doesn't bake, it doesn't bake, you know?]*

Father: *Gompe no, rompe. [Not bake, break.]*

María: *Se me gompe. [It bakes.]*

Father: *Rompe. [Breaks.]*

María: *Guompe. [Bwakes.]*

Father: *Rompe. [Breaks.]*

María: *Gompe. No se me guompe, no se me guompe. [(Bakes. It doesn't bwake, it doesn't bwake.]*

Father: *No. Si le pegas golpes sí que se rompe. [No. If you hit it, it breaks.]*

Semantic corrections: Age: 1.09

Mother: *Chuta. [Kick.]*

María: *Chuta* (throws the ball).

Mother: *Chuta, chutar es con el pié, María, botar es con la mano. [Kick, kick is with your foot, María, throw is with your hand.]*

María: *E pié. [E foot.]*

Mother: *Chutar es con el pie. [Kick is with your foot.]*

Age: 1.10

María: *A mancas a soubá [sleeves to poul up]* (lowering the sleeves of her sweater).

Mother: *No, eso es bajarlas. [No, that's lowering them.]*

The only grammatical correction: Age: 2.03

Mother: *¿A qué le vas a invitar? [What are you going to invite him to?]*

Girl: *Mira, a tomar una caña, parese. [Look, to a beer, think.]*

Mother: *Me parece. [I think.]*

These examples are complemented with what we could call "deafness—of parents—to errors":

Age: 2.01

María: *Si sabo cocinar. [I know cook.]*

Father: *¿Ah sí?, ¿qué sabes hacer? [Oh, yes? What do you know how to cook?]*

Age: 2.01

María: *Voy a cojo una silla. ¿Eta? Eta [I go gets chair. This one? This one.]*

Father: *Oye, ¡qué triciclo más bonito! [Hey, what a pretty tricycle!]*

Although it is obvious that Skinner exaggerated the parents' role, nonetheless, they cannot be discarded as participants in the linguistic development of their children. In the longitudinal study, there are three interesting parent's behaviors that could make up an implicit teaching program:

1. Going down to the child's level: The parents were "imitating" their daughter's proto-language:

Age: 1.08

Mother: *Oye, ¿mamá qué tiene en vez de botas? [Hey, what does mommy have instead of boots?]*

Girl: *Botas. [Boots.]*

Mother: *Los zapatos. Díselo a papá qué son éstos. [The shoes. Tell Papa what these are.]*

Girl: *El nene....apatos. [The baby....'oes.]*

Mother: *Apatos. ['Oes.]*

Girl: *E nene a botas. [The baby a' boots.]*

Mother: *Nene a botas, ¿y mamá? [Baby a' boots. And mommy?]*

Girl: *Nene a botas. [The baby a' boots.]*

Mother: *No, nene botas, ¿y mamá?[No, baby boots; and mommy?]*

Girl: *Mamá apatos. [Mommy 'oes.]*

Mother: *¿Y papá? [And Papa?]*

Girl: *Papá apatos. [Papa 'oes.]*

Mother: *Papá apatos, ¿y el nene? [Daddy 'oes; and the baby?]*

Girl: *¡Bota! As botas. [Boots! A' boots.]*

Mother: *Las botas* (laughing). *[The boots.]*

Age: 1.07

María: *¡Oh e tete!*

Mother: *¡Tete tene la nena! Espera, vamos a quitarle los pantalones. [Oh, the girl has "tete". Wait, let's take off her pants.]*

María: *Nena. [Girl.]*

2. Reinforcing very primitive utterances:

Age: 1.07

Mother: *¿Sabes dónde vamos a ir? [Do you know where we're going?]*

María: *A calle.* [*Utdoors.*]
Mother: *A la calle ¿con quién?* [*Outdoors- with whom?*]
María: *Apá a calle.* [*Ad utdoors.*]
Mother: *Con papá a la calle ¿y con quién más?*[*With dad outdoors and who else?*]
María: *Apá a calle.* [*Ad utdoors.*]
Mother: *Muy bien, ¿y con quién vas a la calle?* [*Very well, and with whom are you going outdoors?*]

Age: 1.07
Mother: *¿Qué tenías en las manos?* [*What did you have in your hands?*]
María: *A má caca.* [*A 'and dirty.*]
Mother: *Claro, pero cuando estabas malita tenías pupa ¿no?* [*Sure, but when you were sick, it hurt, no?*]

3. Developing along with the child:
Age: 1.07
María: *A pá.* [*Ap.*]
Mother: *¿A pá?* [*Ap'?*]
María: *Mn.*
Mother: *Venga, aupa.* [*Come on, up.*]
Age: 2.07
María: *Es que quiero ahí porque ahí no me molesta.* [*I want there because there it doesn't bother me.*]
Mother: *Pero es que si te pones ahí no la ve papá.* [*But if you sit there, papa doesn't see it.*]

This implicit program seems to have the global aim of promoting the child's participation in the communicative exchange. This participation is important because this is how the child receives the language model. Bohannon and Stanowick (1988) pointed out two interesting ways of providing this model—syntactic expansions and semantic extensions—that could even be more informative than the simple grammatical corrections because they offer the correct linguistic model. We will describe them below, with examples in Spanish taken from our longitudinal study.

Expansions: The parents complete the child's utterances
Age: 1.07:
María: *Máa.* (She looks at her hand.)
Father: *¿Eh?*
María: *Caca e má.* [*Ha' dirty.*]
Father: *¿Tienes caca en la mano?* [*Is your hand dirty?*]
Age: 1.09:
Mother: *¿Qué ha pasado?* [*What has happened?*]
María: *Acá.* [*Fell.*]
Mother: *¿Te has caído?* [*Did you fall?*]
María: *Sí.* [*Yes.*]
Mother: *¡Mecachis!* [*Goodness!*]

Semantic extensions: The parents continue the topic initiated by the child.
Age: 1.07:
María: *Aquí e nene.* [*Here a' baby.*]
Mother: *Aquí el nene está muy bien. ¿A qué sí?. Un poquito de jabón para mi nene. ¡Uy jabón!. Dame las manitas.* [*The baby is fine here, right? A little soap for my baby. Oh, soap! Give me your hands.*]
Age: 1.09:
María: *Chupa a meia a guau-guau.* [*Bow-wow lick stocking*]
Mother: *¿Te ha chupado la media el guau-guau?. ¡Mecachis!. Le vamos a hacer tas-tas* [*Did the bow-wow lick your stocking? Goodness! We are going to spank him.*]
Age: 1.09:
Father: ¡Qué ojos tienes, hija! [*What lovely eyes you have, daughter!*]
Girl: *Caca o pes.* [*Dirt a' feet.*]
Father: *Ya, y además de caca en los pies, tienes unos ojos muy bonitos.* [*Yes, and besides dirty feet, your eyes are very pretty.*]

A systematic reinforcing program by parents has not been observed, but instead generalized reinforcement of the child's participation in conversations. Nevertheless, there is no doubt that their contribution as providers of linguistic material on which the child's cognitive system works, is essential. The studies of this material began with the description of motherese, or special speech that adults direct to children, characterized by its simplification, exaggerated tone, and the use of basic vocabulary and simple sentences. Analysis has shown that it is a clear, simple, and well formed speech that could facilitate learning (Snow & Ferguson, 1977). In order to study in detail the relation between motherese and learning, investigations such as that of Pine in 1994 analyze both the children's output and their parents' speech with the aim of determining which part of the adult input the children work on and how they do it.

### *Imitation*

> In the simplest case in which the verbal behavior is under the control of verbal stimuli, the response generates a sound pattern similar to that of the stimuli: for example, when listening to the sound *bearded*, the speaker says *bearded* (Skinner, 1957, p. 55).

Skinner, throughout the text of *Verbal Behavior*, does not talk about imitation, but rather "echoic" verbal behavior. Despite this fact, we will use the word "imitation," as it refers to the same concept.

Skinner treats imitation rather superficially, and his most interesting contribution on this topic is to have popularized this notion, to have guided investigation towards it. Both the first cognitivism (Bruner, 1975) and generativism (Chomsky, 1959) found it easy to criticize the Skinnerian idea of imitation as a mechanism of language acquisition, because this process clearly surpasses the limits imposed by imitation. Therefore, the topic was loaded with negative theoretical connotations: mechanicism, reductionism. Even so, research was not abandoned and currently, imitation is a vital topic both in neurocognition—developmental or otherwise—and in cognitive science (Decety & Sommerville, 2003).

Sticking to imitation in the process of language acquisition, we shall see how the current notion of imitation has changed, it has been reutilized, and has become much more precise.

In the first place, nowadays no one denies that—among other things—children begin to learn language by imitating linguistic examples. The issue is that, in the end, what they learn is the language (the formal conventional system) and not just speech samples. Therefore, imitation plays an essential role in the start of the process and, at the same time, it cannot explain the first grammatical successes, which are partial but combinatory. The following quotation suggests that Skinner guessed at this limitation:

> The first echoic operants acquired by a child tend to be fairly large integral patterns, and they are of little help in permitting him to echo novel patterns echoically. A unit repertoire at the level of separable "speech sounds" develops later and often quite slowly. Small echoic responses may be reinforced by parents and others for the express purpose of building such a repertoire. The child is taught to repeat small sound patters such as ä, sp, and so on. Such a basic echoic repertoire may be acquired at the same time as other forms of verbal behavior or even larger echoic units. The child may emit responses as large as syllables, words, or even sentences as unitary echoic operants. For help in echoing a novel stimulus, however, he falls back upon the single-sound repertoire (Skinner, 1957, p. 62).

The limitation of the Skinnerian treatment of the topic does not make it less interesting. We mentioned that the modern constructivist viewpoints have reused and modified the notion of imitation and its developmental function. Let us see how:

1. Imitation is taken to indicate that the acquisition process of a linguistic structure has *started*, that is, an initial step, before comprehension and production of the said structure (Fraser, Bellugi, & Brown, 1963; López Ornat, 1994). The imitated exemplars can be represented and stored and, therefore, internally analyzed, in search for statistical regularities (López Ornat, 1994, 1999; McClelland & Plaut, 1999; Seidenberg, 1997). In addition, the imitated exemplars must have been perceived, that is, identified within the signal and segmented from it. But the system must also have oriented to these exemplars and selected them.

2. The "predecessor" nature of linguistic imitation seems to be reproduced on the phylogenetic scale: among the hominids, vocal mimicry precedes the emergence of complex articulate language by about two million years (MacWhinney, 2002). Therefore, it seems that the capacity to imitate others' behaviors using fine-tuned sensorimotor coordination, voice, rhythm, and melody, even without understanding/ knowing/ sharing the other's communicative intention (vocal or gestural mimicry), was an evolutionary step prior to the use of complex structured language, such as ours, which would be fairly recent.

3. However, imitation as such is currently considered to develop: for example, in linguistic development, Pérez-Pereira and Castro (1994) distinguish between different types of imitation, which would have different developmental values depending on whether the model is repeated exactly, or it is repeated and extended, or it is repeated and reduced. They also distinguish and compare, for a specific developmental moment in the child, the proportion of productive utterances to routine utterances (Pérez-Pereira, 1994), repetitions, and imitations.

4. Complementarily, in compared cognition (Call & Carpenter, 2003; Tomasello, 2003), various components of imitation are analyzed separately: action, goal, and result. Three types of imitation are differentiated as a function of this: imitation per se (when the subject reproduces the action, the goal, and the result), mimicry (focused on the action), and emulation (focused on the result). In their research with children and chimpanzees, they attempted to arrange these components evolutionarily. Let us see an example of imitation produced by an 18-month old girl:

Action (linguistic utterance): *¿Quieres? ¿Quieres? [Do you want? Do you want?]* (Pregrammatical utterance: the child did not yet produce any person discrimination in the verbal inflection).

Goal (final aim): to get a cookie (She looks at the cupboard, at the adult, and points to the place where the cookies are kept. When the adult gives her the cookie, she stops saying it.)

Result (effect): She gets a cookie

5. There is another "constructivist" distinction portrayed in this example: the time interval between the perception of the model and the child's utterance. This is relevant because it allows us to distinguish deferred imitation (in the example) as more advanced developmentally (Piaget, 1981) than immediate imitation.

6. There is current evidence of what could be part of a neurological support of imitation: the Mirror Neuron System (MNS), first described in adult maccacos. This is a series of neurons that fire not only when the subject performs an action but also when it observes another performing that action. It is tempting to relate this system to a support system of social mimicry, of imitation (Decety & Sommerville, 2003), of Skinner's echolalia. Let us see some intuition of this notion in a fragment of *Verbal Behavior*:

> In the standard "word association" experiment, a stimulus word is presented and the subject is asked to report the first he finds himself saying in response to it. It is necessary to instruct the subject not to repeat the stimulus word; even then, a fragmentary echoic behavior appears in so-called "clang associations"—responses which are alliterative or, rhyming, or otherwise similar to the stimulus word. A fragmentary self-echoic behavior may be shown in reduplicative forms like *helter-skelter*, *razzle-dazzle*, and *willy-nilly*. Pathological echoic behavior is seen in "echolalia," in which a bit of speech heard by the patient is repeated possibly many times. Echoic behavior is most commonly observed in combination with other types of control. In a conversation, for example, a slightly atypical response is often picked up and passed from speaker to speaker. The two

> halves of a dialogue will generally have more words in common than two monologues on the same subject. If one speaker says "incredible" instead of "unbelievable," the other speaker will, in general, and because of the present relation, say "incredible."
>
> A fragmentary echoic behavior is evident when one speaker adopts the accent or mannerisms of another in the course of a conversation. If one member of a group whispers, perhaps only because of laryngitis, other members tend to do so (Skinner, 1957, pp. 35-36).

The existence of a mirror neuron system poses unsolved issues, such as establishing whether the MNS develops phylogenetically or ontogenetically, whether or not it is innate, whether the maccacos' MNS can be compared to that of humans, whether mimic activity is voluntary or involuntary, and so on.

Considering the series or rereadings of the notions of reinforcement and imitation as a whole, we see that a "cognitive wash" has added complexity to these notions, including their gradual changes over the acquisition process.

## Development of Language as a Process of Adaptive Change

> Linguistics has recorded and analyzed speech sounds and semantic and syntactical practices, but comparisons of different languages and the tracing of historical changes have taken precedence over the study of the individual speaker. Logic, mathematics, and scientific methodology have recognized the limitations which linguistic practices impose on human thoughts, but have usually remained content with a formal analysis, in any case, they have not developed the techniques necessary for a causal analysis of the behavior of man thinking (Skinner, 1957, p. 4).

Tomasello (2003), in his book, *A Usage-Based Theory of Language*, proposes that the development of language should be conceived as a series of cognitive processes working on the linguistic input. These processes would be of general domain, that is, they would categorize both linguistic experience and physical and social experience. Thus, the referential and functional roles of language would leave their current "peripheric" position in the theories of language acquisition, and would become first-order explanatory factors. Hence, for Tomasello, semantics and pragmatics should be incorporated at all levels of description, both lexical and morphosyntactic, and at all developmental levels.

But how can one integrate the computational aspects of language (phonology, morphosyntax) with the conceptual ones (semantics, pragmatic, vocabulary) in a theory of linguistic development?

In the seventies, Bruner (1975) initiated a research trend along these lines: From birth, the child is included in communicative acts with the adult. In environments of high functional value (feeding, bathing, playing, etc.), the adult establishes protoconversations with the baby. These formats or routines contribute to language acquisition by directing the child's attention towards language.

Thus, words, like perceptual figures, stand out on a stable, constant, and routine background: the format. In addition, formats are the vehicle of the functionality of language or its adaptive value, taken as the number of problems that its use solves or as the number of problems that cannot be solved because of its lack or deterioration (López Ornat, 1994). For example, Halliday (1973) differentiated among three basic pragmatic functions of infant language: instrumental (*I want*), regulatory (*do what I say*), and interactive (*you and me*).

With regard to meaning, *semantic* bootstrapping or facilitation (Maratsos, 1998; Pinker, 1987), proposes that a series of semantic outlines guide the first grammatical acquisitions. That is, whatever their language, children start talking about the same things. They use their first linguistic expressions to refer to or to code common semantic notions. These are about things existing (attribution, possession, localization) and things happening (actor, action, patient). In an example of infant speech such as *Nene agua pumba* (*[Baby water, splash] I fell into the swimming pool*), the utterance is based on previous semantic notions: agent, localization, action.

However, these attempts to explain grammatical acquisition from pragmatic-semantic learning have never had the force claimed by Tomasello (2003) because they do not solve the problem of continuity between these acquisitions and complex grammatical acquisition.

As we shall see in the following phrases, Skinner (Cohen, 1977) did not contemplate any qualitative leap between both types of knowledge (pragmatic and grammatical). Thus, he established a distinction between behavior molded by contingencies and behavior occurring when people follow rules extracted from these contingencies. According to Skinner, rational behavior would imply providing reasons, which are sentences about the contingencies. One can manipulate rational behavior very well, as it is very similar to behavior molded by contingencies, but with a difference. Skinner also stated that people learn to extract rules and justify why they follow them (Cohen, 1977).

Thus, it seems that, for Skinner, the process of grammaticalization would be described as a process of cognitive organization to maximize the positive consequences of the child's action on the environment. Verbal behaviors are classified as a function of this behavioral goal instead of as a function of linguistic criteria. We shall see the two most representative classifications:

MANDs, which refer to the pragmatics of language: "In a given verbal community, certain responses are characteristically followed by certain consequences. 'Wait!' is followed by someone's waiting and 'Sh-h!' by silence" (Skinner, 1957, p. 35).

TACTs, which refer to the semantics of language: "The term carries a mnemonic suggestion of behavior which "makes contact" with the physical world" (Skinner, 1957, p. 81).

Both Skinner's model and the constructivist model include semantic and pragmatic variables in the center of linguistic development. For both models, the development of grammar should be contextualized. Table 1 displays an example of the development of the imperative formulas (Gallo, 1994b), comparing the two types of knowledge: semantic and grammatical.

The constructivist model, which has slowly become an alternative to the Chomskian model, is in accordance with the Skinnerian conception, much revised and extended, of linguistic learning as a process of ontogenetic, gradual, and adaptive change. The functionality that penetrates the entire Skinnerian model is again claimed after many years during which the predominant focus of interest was excessively formal. According to Rivière (1991), the notion of a system that incorporates logical principles into its neural networks calls for concordance with the properties of the central nervous system. From this perspective, two properties stand out: adaptability, synonym of flexibility and ontogenetic change, and intentionality, synonym of meaningful activity.

In addition to the above-mentioned contributions, the importance of Skinner's work consists of its having turned–definitively–human behavior into an object of study, unshackling it from the spirit. Its merit is not to have been a pioneer in this attitude, but to have divulged it, turning scientific inspection of human activity into something natural. And he did this with wit. In 1934, Whitehead challenged Skinner to functionally explain the following linguistic utterance: *No black scorpion has fallen on this table.* He accompanied this utterance with the following comment: "Science can explain any human behavior except for verbal behavior." Skinner replied that to ask such a thing of behaviorism was "unfair" (Skinner, 1957, p. 457) and wrote that the very next morning, he began to write *Verbal Behavior*.

Table 1
*Development of the Imperative Formulas. Comparison of Semantic and Grammatical Knowledge. (Gallo 1994b)*

| Age | Semantic Knowledge | Morphosyntactic Knowledge | Example |
|---|---|---|---|
| 1.09 | Action | Imperative | *Sienta [sit]* |
| 1.10 | Action + Person | Clitics<br>2nd Person | *Pome [Put on me]*<br>*Sientas [You sit]* |
| 2.01 | Negation | Subjunctive | *No te vayas [Don't go]* |
| 2.04 | Consequence | Subordinate | *No jubas, la tiro la tapa*<br>*[Don't come up or I throw away the top]* |

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# Linguistic variation and micro-cues in first language acquisition

Marit Westergaard
University of Tromsø

Children are often exposed to considerable variation in the input. Nevertheless, there is very little overgeneralization in child language data and children are typically found to make errors of omission, not errors of commission, a fact which is often referred to as conservative learning. In this paper, these findings are accounted for by a model of micro-cues, a generative approach to language acquisition arguing that children are sensitive to fine syntactic distinctions from early on. The micro-cues are small pieces of abstract syntactic structure resulting from parsing the input. This means that UG provides children with principles, features, and the ability to parse, but not the micro-cues themselves, which are considered to be part of the knowledge of a specific language. The model also considers children's errors to generally be due to economy and the language acquisition process to be development in small steps, from specific to more general knowledge.

**Keywords:** Conservative learning; economy; English; grammar competition; Norwegian; (over- and under)generalization; parameter; rule "size"; word order

## 1. Introduction

While traditional generative theory has mainly been concerned with variation across languages, variation within languages is not uncommon. Thus, children are typically exposed to considerable variation in the input. Based on findings from the acquisition of such variation, this short paper discusses and further develops the model of micro-cues in language acquisition (Westergaard 2009a, 2013). The main focus of the paper is on principles of economy, aspects of conservative learning, and arguments that the acquisition process is a stepwise development from specific to general knowledge.

The paper is organized in the following way: In the next section, I give a brief overview of some child data on word order patterns that involve variation in the input, showing that children generally make fine distinctions in syntax and

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information structure from early on (Westergaard 2009a, c, 2011; Anderssen & Westergaard 2010, 2012; Westergaard & Anderssen forthcoming). In Section 3, I discuss the occasional errors that are typically found in child language data and argue that most of these are due to a principle of economy in the acquisition process, and I relate this to the idea of conservative learning (Snyder 2007). In Section 4, I discuss the idea of grammar competition (Yang 2002, 2010), arguing that it generally predicts massive overgeneralization in early child data and that competition must therefore be restricted to low-level variation, i.e. affecting very small parts of the grammar. I then outline the model of micro-cues and the idea of 'learning by parsing' (Fodor 1998; Lightfoot 1999, 2006; Westergaard 2009a). Finally, in Section 6 I briefly compare traditional generative accounts to constructivist accounts of language acquisition and argue that learning is from specific to general (Ambridge & Lieven 2011; Westergaard 2013) and not the other way around (Biberauer & Roberts 2012). Section 7 is a brief conclusion.

## 2. Variation in the input

In traditional generative theory, variation across languages is accounted for by the existence of parameters provided by Universal Grammar (UG); see e.g. Chomsky (1981, 1986), Snyder & Lillo-Martin (2011). These are typically considered to be mental switches for aspects of grammar where languages differ, e.g. whether heads precede or follow their complements (head parameter), whether subjects may be null or not (pro-drop parameter), or whether verbs have to appear in second position (V2 parameter). The switches will be turned to the correct value as a result of exposure to a particular language early in the language acquisition process (Wexler 1999). On this view, children's errors are often considered to be due to parameter mis-setting; see e.g. Hyams (1986) for one of the most cited examples of this, where she argues that subject omissions in the early production of children learning a non-prodrop language is due to a mis-setting of the prodrop parameter. The idea of parameter mis-setting has turned out to have a number of problems; see e.g. Valian (1990, 1991) for a thorough discussion of Hyams' account.

There is also considerable variation within languages. For several years, the acquisition research group at the University of Tromsø has been concerned with how children deal with variation in the input, especially in the domain of word order. The most important research questions that have been addressed are whether children have an early preference for one of the two options, possibly indicating parameter setting, and how early they master the often fine distinctions between the two word orders in the adult language, with respect to both syntax and information structure. Here I will briefly overview some work on variable verb second (V2), different subject positions (subject shift), and word order variation inside the DP (possessives), but the group has also produced relevant work on object shift (Anderssen, Bentzen & Rodina 2012; Anderssen & Bentzen 2012; Bentzen, Anderssen & Waldmann 2013), object scrambling (Mykhaylyk 2011, 2012), embedded clause word order (Westergaard & Bentzen 2007; Westergaard 2009a) and double object constructions (Mykhaylyk, Rodina & Anderssen 2013; Anderssen, Rodina, Mykhaylyk & Fikkert 2014).

It is well known that V2 word order is not obligatory in Norwegian (e.g. Vangsnes 2005; Westergaard 2009b). The variation is dependent on factors such as clause type (e.g. declarative vs. wh-question), the initial constituent (e.g. phrasal vs. monosyllabic wh-elements), and information structure (whether the subject conveys given or new and/or focused information). Investigating the spontaneous utterances of three children in an acquisition corpus (Anderssen 2006), Westergaard (2009a) finds that all three children produce target-consistent V2 as well as non-V2 word order in appropriate contexts from early on, without any overgeneralization. For example, if the initial element in a declarative is the adverb *kanskje* 'maybe', the target language allows both V2 and non-V2 word orders, but speakers prefer non-V2 as often as approximately 95% (cf. Westergaard 2008b), while all other non-subject-initial elements (adverbs, objects, etc.) require V2. Examples (1) and (2) illustrate that the children produce non-V2 with initial *kanskje* 'maybe', while V2 is produced with other non-subject-initial material (here the adverb *no* 'now'), and according to Westergaard (2008b, 2009a), the proportions of each word order in the child data are more or less the same as in adult child-directed speech.

(1) *kanskje det var en anna dag.* (Ina.09, age 2;2.12)
maybe it be.PAST an other day
'Maybe it was another day.'

(2) *no er det borte.* (Ina.06, age 2;1.0)
now be.PRES it gone
'Now it is gone.'

In wh-questions, there is even more word order variation: Although the standard language requires V2, non-V2 is widespread in most parts of the country (cf. e.g. Westergaard, Vangsnes & Lohndal 2012). There is considerable micro-variation across dialects, but a common distinction is that V2 is required if the wh-element is long (more than one syllable), as in (3), while both word orders are grammatical if the wh-element is monosyllabic; see (4a–b). Westergaard (2009b) uses the Head Principle of van Gelderen (2004) to argue that this distinction is due to monosyllabic wh-words being heads and longer wh-elements being phrases. This means that the monosyllabic wh-words may move into the head position that the verb normally moves to (the head of the Interrogative Phrase), thus blocking (generalized) V2.

In contexts where both word orders are allowed, the choice between the two is dependent on information structure: More specifically, non-V2 is used if the subject has been mentioned in previous discourse and thus conveys given information (typically a pronoun, as in 4b) and V2 if the subject expresses new information (often a full DP, as in 4a). V2 may also be used with given subjects if they are focused or contrasted. Westergaard (2009b) thus argues that a lower functional head is involved (the head of the Topic Phrase), attracting the verb only when the subject conveys new and/or focused information. Although there is quite a bit of variation across different speakers with respect to the frequency of V2 in this context (between 2.5% and 68.4% in the data investigated in Westergaard 2009b), children are typically exposed to considerable proportions of both word orders. The three children in the acquisition corpus seem to have no problem producing V2 and non-V2 in appropriate contexts, as shown by the following examples.

(3) *koffer* ***har*** ***han*** *fått den?* (Ina.22, age 2;10.2)
why have.PRES he got that
'Why did he get that?'

(4) a. *kor* ***er*** ***Ann sin dukke*** *hen?* (Ann.04, age 1;11.0)
where be.PRES Ann POSS doll LOC
'Where is Ann's doll?'

b. *ka* ***du*** ***gjør?*** (Ann.10, age 2;3.9)
what you do.PRES
'What are you doing?'

Norwegian also displays word order variation with respect to the position of the subject in all non-subject-initial sentences with V2, i.e. wh-questions and non-subject-initial declaratives. If negation or another adverb is present, the subject may either precede or follow this element, i.e. the word order is either XP-V-Neg-S or XP-V-S-Neg. The choice of word order is again dependent on information structure, informationally new and/or focused subjects (typically DPs) following negation and given subjects (typically pronouns) preceding negation. This is sometimes referred to as subject shift (e.g. Westergaard 2008a, 2011), involving movement of an informationally (and often prosodically) light subject to the higher position. In spontaneous discourse, the high subject position is considerably more frequent than the lower position, since subjects tend to be given information. In the Tromsø acquisition corpus (Anderssen 2006), the high subject position is attested 81% (1351/1667) in relevant utterances in the adult data. The three children in the corpus are sensitive to this distinction from early on (Westergaard 2008a; Anderssen & Westergaard 2010; Westergaard 2011), typically producing DP subjects in the low position (following negation) and pronominal subjects high (preceding negation), as illustrated in (5) and (6).

(5) *korfor kommer* ***ikke mummien*** *sæ laus?* (Ole.17, age 2;8.24)
why come.PRES not mummi.DEF REFL loose
'Why is the Mummi troll stuck?'

(6) *og no kan æ* ***ikke*** *drikke det.* (Ole.19, age 2;10.0)
and now can I not drink it
'And now I can't drink it.'

Word order variation is also found inside the DP, in that the possessor may either precede or follow the head noun, depending on whether the possessor is topical or focal, yielding N-POSS and POSS-N word orders respectively; cf. Lødrup (2011), Anderssen & Westergaard (2010). Investigations of corpora of spontaneous speech reveal that the postnominal possessor construction (N-POSS) is far more frequent than the prenominal one in children's input, being attested approximately 75% (Anderssen & Westergaard 2012; Westergaard & Anderssen forthcoming). Nevertheless, the corpus data investigated reveal that the children produce both word orders from early on, as shown in (7a–b). The interpretation of (7a) would be that the possessor is focused and contrastive (*my* dress, not somebody else's), while the possessive relationship in (7b) is neutral/non-contrastive.

(7) a. *det er* ***min kjole.*** (Ina.07, age 2;1.23)
it is my dress
'It is my dress.'

b. *nei no dætt ned mannen på*
no now fall down mann.DEF on
***foten min.*** (Ina.08, age 2;1.29)
foot.DEF my
'Oh no – now the man is falling down on my foot.'

To conclude this section, the data from children's spontaneous production of word order variation, both at the clausal and the phrasal level, show that they produce both options from early on. Furthermore, they generally produce the two word orders in appropriate contexts. In these domains, therefore, there does not seem to be any evidence that children are setting (or mis-setting) parameters, which would have resulted in massive and indiscriminate overgeneralization of one of the word orders in early production.

## 3. Economy and conservative learning

Considering the data reviewed in the previous section, one may ask whether children *ever* make mistakes in spontaneous production. In fact, they do. But most of their errors are of a particular type. In the three domains discussed in the previous section, verb placement, subject placement and the position of the possessor in relation to the noun, young children have been found to occasionally produce the element in question in a lower position than what the target language requires. Example (8) shows that the verb has failed to move across the subject to verb-second position in a declarative, (9) shows a pronominal subject in a position following negation, and (10) shows that the child produces POSS-N word order (without N-movement across the possessor) in a context where the adult investigator produces N-POSS.

(8) *nå æ* ***skal*** *(s)t(r)ikke litt til.* (Ole.10, age 2;4.6)
now I shall knit little more
'Now I will knit a little more.' Target: Nå skal æ strikke litt til.

(9) *det får ikke æ lov til.* (Ole.12, age 2;5.18)
that get.PRES not I allowed to
'That I am not allowed to do.' Target: Det får æ ikke lov til.

(10) a. Ina: *i* ***min munn.*** (Ina.20; age 2;8.27)
in my mouth
'Into my mouth.' Target: I munnen min.

b. Inv: *ja og opp i* ***munnen din.***
yes and up in mouth.DEF your
'And into your mouth, yes.'

The examples in (8)–(10) all illustrate lack of syntactic movement. Similar findings have been attested in children's production of object positions (e.g. Anderssen, Bentzen, Rodina & Westergaard 2010). Thus, I have claimed (e.g. in Westergaard 2009a) that this production is not due to a defect in the children's I-language grammar, such as a mis-set parameter. Instead this is argued to be due to a 3rd factor (Chomsky 2005), commonly seen in the process of language acquisition: Economy. That is, children are economical in their production and will not produce an element, perform a movement operation or build syntactic structure, unless there is clear evidence for it in the input. This means that there is little or no overgeneralization in child language data; in fact, we often find the opposite. Roeper (1999:175) also notes that there is widespread evidence for "undergeneralization" in child language.

Similarly, Snyder (2007) provides an overview of a number of language acquisition studies, focusing on very different areas of grammar than we have done here, e.g. verb-particle constructions in English or preposition stranding vs. pied-piping in English and Spanish. Snyder (2007) convincingly shows that children's errors are generally restricted to errors of omission, while the number of errors of commission is negligible in child language data. He refers to this as 'grammatical conservatism' and argues that traditional approaches to learnability, such as the Trigger Learning Algorithm (Gibson & Wexler 1994), are not sufficient to explain the acquisition process of a conservative learner, since such approaches necessarily predict massive errors of commission as the child moves from one grammar to another (sets and resets parameters). Instead, Snyder suggests that the ideas proposed in Fodor (1998) may be compatible with conservative learning: Fodor argues that children's initial grammars are endowed with small pieces of syntactic structure, so-called 'treelets', and that children use these to identify possible parses for the input that they are exposed to. If the parse is unambiguous, the grammar will use this to set a parameter. This is referred to as "learning by parsing" and will be returned to in Section 5 below, as it is in principle very similar to the idea behind the micro-cue model.

Finally in this section, I would like to point out that children's economic lack-of-movement errors are not always random. Occasionally it is possible to find that children make certain distinctions in their non-target-consistent production that are not reflected in the input. For example, when V2 fails in Norwegian or Swedish child language, this typically happens when the subject is a pronoun and/or the verb is another verb than *be*, as in (8) above (Westergaard 2004; Waldmann 2008, 2011). This means that V2 word order is initially preferred with *be* and DP subjects, just like the target-consistent V2 in wh-questions. This preference is relatively short-lived but found to be statistically significant (Westergaard 2009a). It has also been argued that some English-speaking children's lack of subject-auxiliary inversion is systematically related to certain wh-items, typically distinguishing between *what* and *where* on the one hand, which trigger inversion early and almost consistently, and *why* on the other, which triggers inversion only at a much later stage (e.g. de Villiers 1991; Thornton 2008; Westergaard 2009c). A significant distinction has also been found between *be* and auxiliaries in English children's wh-questions (e.g. Westergaard 2009c, forthcoming). This means that children are *systematically* undergeneralizing, i.e. producing less movement than what is required in the target language.

## 4. Grammar competition and the "size" of rules

Roeper's (1999) seminal article on "universal bilingualism" introduced the idea that monolingual children who are exposed to variation in the input may entertain two different grammars for an extended period of time. For example, English children are exposed to a grammar where the verb *be* inverts with the subject, but other lexical verbs do not, as illustrated in (11)–(12).

(11) Where is she?

(12) *What drinks she?/What does she drink?

By comparison, German children are exposed to a grammar where all lexical verbs invert, and they are thus assumed to set the V2 parameter to its positive value at an early stage. English-speaking children, on the other hand, will have to have a lexically restricted V2 grammar (affecting *be* and a few other verbs), while at the same time entertaining a productive non-V2 grammar applying in all other cases. Roeper (1999: 184) also shows that there are many other "pockets of bilingualism ... within Standard English", and this means that all monolingual speakers must have a grammar that has certain bilingual properties.

In the spirit of this idea, Yang (2002) has developed an approach to language acquisition called the Variational Model, combining UG and statistical learning (see also Yang 2010). On this view, children are endowed with a highly specified UG where all possible human grammars are represented; e.g. for pro-drop, children may choose between an Italian-type pro-drop language (with rich agreement), a Chinese-type pro-drop language (which also allows object drop), and a non-prodrop grammar such as English. Like Snyder (2007), Yang (2010: 134) argues against a triggering approach to parameter setting, as this would predict "sudden qualitative and quantitative changes in children's production", which are generally not attested in child language data. Instead, children keep track of the input that favors one or the other grammar and use statistical evidence in the input to strengthen or demote them: For example, a child learning English will relatively quickly discard an Italian-type pro-drop grammar, as English does not have rich agreement and this is evident in almost every sentence. A Chinese-type pro-drop grammar will take somewhat longer to rule out, as the necessary evidence is only found in sentences with expletive subjects, and children encounter such sentences in the input much more rarely (1.2%, according to Yang 2010: 135).

According to Snyder (2007), the Variational Model is successful in analyzing areas of the grammar where children typically omit material that would be required in the adult language (such as subjects and objects). However, the model predicts "rampant errors of commission in other parts of the grammar" (Snyder 2007: 185). In my view, it is also problematic that all possible grammars have to be provided by UG. This would entail an extraordinarily high number of different grammars in UG, as e.g. not all null-subject grammars are like Italian or Chinese: For example, Russian, Hebrew and Inuktitut all allow null subjects under conditions that are somewhat different from those found in Italian and Chinese (Gordishevsky & Avrutin 2004; Allen & Schröder 2003). It has also recently been argued that there is systematic micro-variation between Spanish and Italian with respect to the interpretation of pronominal subjects (Filiaci, Sorace & Carreiras 2014). Nevertheless, children learning all these languages very early zoom in on the target grammar. Furthermore, to my knowledge, there is no evidence in the literature that (monolingual) children ever produce more overt subjects that the target language, which might have been expected if children could (more or less randomly) select any parameter setting provided by UG; instead, in all cases they typically drop subjects slightly more than adults. In my view, this could simply be considered to be a result of children's general tendency for economy.

When there is variation in the input, some kind of grammar competition seems to be inevitable. But given findings from acquisition data such as those reported in Snyder (2007) and in the work of the Tromsø research group mentioned in Section 2, children very early make the crucial distinctions that exist in the target grammar and produce the two (or more) options *in appropriate contexts*. To return to the example of V2 in Norwegian discussed in Section 2, the children do not seem to be computing the overall percentages of V2 vs. non-V2 in the input and indiscriminately weighing the two grammars (in terms of the setting or re-setting of a macro-parameter), but are sensitive to the linguistic contexts that the different word orders appear in. Thus, given that children master these fine distinctions from early on, there is very little evidence for grammar competition in child language data. As I have argued in Westergaard (2014), this shows that children do not initially expect there to be competing forms in the input, but instead assume that they are exposed to principled variation and therefore try to figure out what this is based on. This means that grammar competition should not be the initial hypothesis of a child on exposure to variation, but rather a *last resort*, to be entertained only when children fail to find a distinguishing property between the options.

Nevertheless, there must obviously be some grammar competition in language, for example in cases where there is free variation in the target grammar, such as the optionality between V2 and non-V2 after the adverb *kanskje* 'maybe' (see Section 2). In these cases, children seem to be quite good at statistical learning, producing the two options with similar frequencies as in the adult data from early on (96.4% (27/28) non-V2 compared to approximately 95% in the adult language; cf. Westergaard 2008b, 2009a). Thus, in my view, grammar competition (and the corresponding statistical learning) does not apply at the level of macroparameters, but should be restricted to cases of low-level variation, where the differences are quite small, affecting a subcategory, a feature or a lexical element rather than major categories.

This means that the "size" of rules is crucial. In Biberauer & Roberts (2012) and related work, the concept of parameter is broken down into a hierarchy of four distinct types, dependent on the size of the context in which they apply. That is, parameters may be macro, meso, micro or nano, depending on the class of elements that undergo the relevant process: (1) all elements of a given type, e.g. all heads in the language (macroparameter), (2) a featurally specifiable subset of the elements of this category, e.g. all verbs or all nouns (mesoparameter),

(3) the smallest definable sub-class of elements of this category, e.g. auxiliaries or pronouns (microparameter), and (4) one or more individual lexical items (nanoparameter).

Biberauer & Roberts (2012) mainly discuss verb movement, and identify the V-to-I movement operation found in earlier stages of English as well as many present-day languages, e.g. French, as a mesoparameter. This rule moves all heads of the verbal category to a higher functional position, resulting in a word order where the finite verb precedes negation and other adverbs, as shown in (13). In present-day English, this operation has been reduced to a microparameter, affecting auxiliaries only, that is, a subclass of verbal elements. An example of subject-auxiliary inversion is provided in (14).

(13) if I **gave not** this accompt to you (Early Modern English, 1557)
if I gave not this account to you
'if I didn't give this account to you'

(14) John **has not** kissed Mary.
(Examples from Biberauer & Roberts 2012: 271–2)

The historical development from (13) to (14) also displayed a stage where certain lexical verbs still underwent the movement operation, e.g. *know* and *doubt*. This corresponds to a nanoparameter, affecting only specific lexical items in the language. Finally, at the other end of the hierarchy, Biberauer & Roberts (2012: 276) provide generalized head movement as an example of a macroparameter: The positive value of this parameter would entail syntactic movement to all heads, which is found in some polysynthetic languages. The other value of this macroparameter is found in languages that have no head movement at all, e.g. Mandarin and other Chinese varieties.

According to Biberauer & Roberts (2012), parameters are not given by UG, but considered to be emergent properties, resulting from the interaction of a minimal UG, the primary linguistic data and certain 3rd factors (Chomsky 2005), e.g. what Biberauer & Roberts refer to as acquisition strategies. In my view, breaking down major parameters into processes that affect smaller parts of the grammar is a promising development within generative theory, given the micro-variation that has been found to exist between different languages, especially as a result of many dialect studies in recent years, and also given findings from language acquisition research showing that children cope quite well with such variation. Thus, I believe that in order to gain further understanding of language variation and language acquisition, our studies should focus on the micro-level; i.e. at the level where variation is dependent on fine linguistic distinctions between subclasses of categories.

## 5. A model of micro-cues

In recent work, I have developed a model of language acquisition based on children formulating micro-cues in their I-language grammars (e.g. Westergaard 2009a, 2013). The model is inspired by Lightfoot's (1999, 2006) cue-based theory of acquisition and change. In this theory, a cue is a piece of abstract syntactic structure, formulated as in (15) for the word order Object-Verb (corresponding to the head parameter) and (16) for V2 word order.

(15) Cue for OV word order: $_{VP}$[DP V]

(16) Cue for V2 word order: $_{CP}$[XP $_{C}$V...]

According to Lightfoot, the cues are provided by UG; thus, children know what to look for in the input that they are exposed to. This means that the cues do not correspond to input strings. The input serves as *triggers* for cues that are already present in UG, some of which will be activated in the language acquisition process and others that will not. Lightfoot (2006: 78) formulates it in the following way: "a sentence EXPRESSES a cue if the cue is unambiguously required for the analysis of the sentence." This means that the child's primary linguistic data are the triggering experience, while the cues are mental representations in the child's I-language.

Lightfoot's cue-based theory is similar to Fodor's (1998) idea of treelets as unambiguous triggers, mentioned in Section 3 above. A treelet is similar to a cue in that it is defined as "a small piece of tree structure (a few nodes, perhaps only partially specified in features; in the limiting case a single feature) that is made available by UG and is adopted into a learner's grammar if it proves essential for parsing input sentences." (Fodor 1998: 6). This means that both cues and treelets are assumed to be innate structural templates. In Fodor's system, the treelets represent parametric options provided by UG, and each treelet will thus trigger a specific parameter setting. In Lightfoot's theory, on the other hand, "cues ... are the points of variation between grammars and there is no need for an independent notion of a parameter." (Lightfoot 2006: 78).

Lightfoot's cues are formulated in terms of major categories such as V or DP, and for this reason they make the same predictions as traditional macro-parameters. But the child language data discussed in Section 2 show that children are sensitive to much finer distinctions than that. In my view, therefore, if a theory is to account for variation, it is necessary to formulate a number of much smaller cues, that is, micro-cues. In the model of micro-cues, the context for a particular word order (e.g. V2 or non-V2) needs to be specified as part of the cue. This captures the fact that children do not only need to acquire a specific word order, but also the contexts in which this word order is relevant. Examples of such micro-cues are provided in (17)–(21), accounting for the micro-variation discussed in Section 2.

(17) Micro-cue for V2 in wh-questions with monosyllabic wh-elements: $_{\text{IntP}}[_{\text{Int0}}[wh]\ _{\text{TopP}}[_{\text{Top°}}[\text{V}\ldots\ \text{XP}_{[+\text{FOC}]}\ \ldots]]]$

(18) Micro-cue for V2 in declaratives: $_{\text{DeclP}}[\text{XP}\ _{\text{Decl°}}[\text{V}\ \ldots]$

(19) Micro-cue for word order in declaratives with clause-initial *kanskje* 'maybe': $_{\text{TopP}}[\textit{kanskje}\ \text{XP}\ \ldots\ _{\text{VP}}[\text{V}]]$

(20) Micro-cue for subject shift: $_{\text{InTopP}}[\text{DP}_{[-\text{FOC}]}\ \ldots]$

(21) Micro-cue for N-POSS word order: $_{\text{DP}}[\text{N-DET POSS}_{[-\text{FOC}]}\ \ldots]$

Both Fodor (1998) and Lightfoot (1999, 2006) state that for cues or treelets to be able to trigger a particular structure (or parameter), they must be unambiguous. Fodor (1998:6) formulates this as a principle of acquisition in the following way: "one absolute rule for language learners is *Do not learn from ambiguous input.*" She refers to her model as a "wait-and-see device", which, unlike the Triggering Learning Algorithm of Gibson & Wexler (1994), makes no changes in the child's grammar when the input is ambiguous. In the micro-cue model, this requirement for unambiguous cues is captured by adding relevant context into the formulation of the cue itself. This is also discussed in Westergaard 2008b, 2009a), where I have argued that children search for micro-cues only in constructions or clause types where there is clear evidence. For example, in order to formulate a micro-cue for V2 word order, children only consider non-subject-initial sentences, as only these will contain relevant information, while SVO sentences will simply be disregarded in this respect. This means that children must have the ability to parse the input and distinguish between ambiguous and non-ambiguous cues. This ability will also reduce the amount of grammar competition in children's grammars. In the micro-cues formulated above, only (18) and (19) are in conflict with each other, specifying the word order in non-subject-initial declaratives (in general) and the particular word order found in declaratives introduced by the adverb *kanskje* 'maybe'. For the other micro-cues, the specification of the context ensures that there is no competition.

An important difference between Lightfoot's (1999, 2006) cue-based theory and Fodor's (1998) treelets on the one hand and the micro-cue model on the other is that the former models assume that the cues or treelets themselves are provided by the innate language faculty. In the micro-cue approach, on the other hand, the micro-cues are considered to be language-specific. In fact, they must be, given that they in some cases refer to particular lexical items, e.g. the micro-cue in (17), providing information about the word order in declaratives introduced by the adverb *kanskje* 'maybe'. Children are clearly sensitive to information at this level of detail from early on, and this must therefore be part of their linguistic knowledge, that is, their I-language. This means that the micro-cues represent a speaker's knowledge of a *specific* language. However, the micro-cues are made up of syntactic primitives and built according to principles provided by UG. This makes the micro-cue model different also from constructivist accounts, which typically claim that children are not endowed with any innate knowledge of categories or structure (e.g. Ambridge & Lieven 2011).

Thus, the micro-cue model is a generative approach which assumes the existence of a UG consisting of syntactic primitives (categories, features) and general principles of structure building.[1] This innate endowment is in some sense restricted compared to what is assumed in more traditional generative accounts, in that UG does not contain any parameters, nor does it provide the learner with any pre-built cues or treelets. But UG is still quite rich, in that it enables children to *parse* the primary linguistic data that they are exposed to. In parsing the input, children select the relevant primitives from the universal set and build syntactic structure based on the principles provided by UG. The micro-cues are small pieces of syntactic structure that result from this parsing. In turn, they trigger the syntactic operations necessary to produce the relevant target structures, e.g. verb movement or subject shift. The language acquisition process is also affected by so-called 3rd factors (Chomsky 2005), for example general cognitive limitations (such as memory) or principles of economy, as discussed in Section 3. Under this approach, language acquisition is considered to be what Snyder (2007) refers to as 'learning by parsing', and it typically results from an interaction between UG, input, and economy.

## 6. From specific to general and general to specific

One important issue within the field of first language acquisition is the question whether the child's development is from knowledge of general principles to knowledge about more specific details of the ambient language or the other way around. A traditional generative approach to acquisition assuming parameter setting will generally consider development to be from general to specific; that is, parameter setting is early and automatic and based on very little input (e.g. Wexler 1999), while any language-specific exceptions will have to be learned from more extensive exposure to the input and will therefore take longer. Constructivist accounts, on the other hand, which assume no linguistically specific genetic endowment,

1. An anonymous reviewer asks how specific these features are in the micro-cue model. In my view, that is an empirical question, which we may find answers to by studying children's fine-grained distinctions that are not in the input (that is, their undergeneralization).

argue that development is from specific to more general; that is, early multi-word utterances are initially item-specific, then develop into frames or schemas with slots for different word types and only gradually become more abstract and general (e.g. Tomasello 2003, 2006).

The micro-cue model recognizes a relatively rich UG and argues that children's early grammars have categories/features, structure and rules. Nevertheless, the model is similar to constructivist accounts in that it assumes that development is from specific to general. The main reason for this is the conservative nature of children's production, indicating that they do not generalize a pattern or a rule until they have encountered positive evidence for this in the input.

In Section 4, I discussed the new syntactic model proposed by Biberauer & Roberts (2012), where parameters are split up into four kinds of rules depending on size (macro, meso, micro and nano). The top of the parameter hierarchy involves less specific knowledge than the lower levels; that is, lower positions in the hierarchy have longer and more detailed descriptions and are therefore more complex. This means that setting a macroparameter is simpler than setting a parameter at the meso-level, which is again simpler than parameters at the micro- or nano-levels. There is especially one factor that is of importance in this respect, viz. the Input Generalization, formulated in the following way (Biberauer & Roberts 2012: 269, originally from Roberts 2007).

(22) Input Generalisation (IG): If a functional head F sets parameter $P_j$ to value $v_i$ then there is a preference for similar functional heads to set $P_j$ to value $v_i$.

The Input Generalization ensures that there is a strong tendency for all functional heads to point in the same direction. Biberauer & Roberts (2012) relate the simplicity of this to the conservativeness of the child in the acquisition process. The higher levels represent the least amount of linguistic knowledge on the part of the learner and are thus assumed to "represent the acquirers' initial hypotheses" (Biberaurer & Roberts 2012: 270). Thus, these will be "automatically 'chosen' by the acquirer based on early 'ignorance'" (Biberauer & Roberts 2012: 270–271). The process of language acquisition then involves the learner moving down the hierarchy, making more and more fine-grained distinctions.

But children's conservative learning is usually used to refer to the opposite process, that is, the lack of (over-)generalization. This was seen in the work referred to above (e.g. Snyder 2007; Westergaard 2013; Roeper 1999). And in the constructivist literature, there are numerous reports of especially experimental studies in which children are found not to generalize across the item-specific knowledge that they possess at a specific stage (see e.g. Ambridge & Lieven 2011). I would therefore argue that the Input Generalization cannot be a general property of language acquisition and that it must be severely modified.

Nevertheless, we also know that the adult language is not simply accumulated knowledge of a high number of specific constructions; it also consists of a productive grammatical system. This means that there must be a certain generalization taking place at some point in the acquisition process. In the micro-cue approach, this kind of generalization is considered to be development in a stepwise fashion. The crucial point is that these steps are small, involving only the addition of a new sub-category, a new lexical item or an extra feature. For example, given the cases of undergeneralization that we saw in Section 3, an initial formulation of the micro-cue for word order in Norwegian or Swedish declaratives could be as in (23), specifying that V2 appears in sentences with the verb *be* and DP subjects. Since V2 is a more general process in the target version of the two languages, affecting all verbs and all subjects, this micro-cue must be extended to the formulation that we saw in (18), repeated here as (25), possibly with an intermediate stage where V2 is generalized to all subject types but still only applying to the verb *be*, as in (24).

(23) Micro-cue for V2 in declaratives (initial version): $_{\text{DeclP}}$[XP $_{\text{Decl°}}$*be* ...[DP ...]

(24) Micro-cue for V2 in declaratives (intermediate version): $_{\text{DeclP}}$[XP $_{\text{Decl°}}$*be* ...]

(25) Micro-cue for V2 in declaratives (adult version): $_{\text{DeclP}}$[XP $_{\text{Decl°}}$V ...]

Similarly, the micro-cues for subject-auxiliary inversion in English wh-questions could be formulated as the developmental process illustrated in (26)–(28): This shows development from an item-based process, affecting the wh-words *what* and *where* first as well as the lexical verb *be*, via a stage where the verbal element is generalized to also include auxiliaries (that is, all elements that appear in the I position in English), and finally to a stage where the initial element is generalized to include all wh-items.

(26) Micro-cue for inversion in wh-questions (initial version): $_{\text{IntP}}$[*what/where be* ...]

(27) Micro-cue for inversion in wh-questions (intermediate version): $_{\text{IntP}}$[*what/where* I ...]

(28) Micro-cue for inversion in wh-questions (adult version): $_{\text{IntP}}$[WH I ...]

There may of course be many more steps in the process than what is indicated here, and the order may also be different. The duration of the various stages will vary from child to child and also clearly be dependent on the frequency with which a child is exposed to positive evidence in the input that the current formulation of a micro-cue should be generalized. However, given the general speed of language acquisition, the small steps in the development should typically be short-lived. For this reason, the evidence for this kind of development should be sought in very dense corpora of spontaneous child speech, which are unfortunately not abundant among the existing resources to date.

Finally, an important question is whether children never *over*generalize? Given their sensitivity to the input combined with conservative learning, examples of overgeneralization are also quite difficult to find in child language data. One that has been attested involves verb movement in English, which, as I argued above, normally does not generalize beyond what there is positive evidence for in the input; that is, it only extends from *be* to auxiliaries. Nevertheless, Roeper (1999) has attested occasional examples of inversion with the verbs *mean* and *call* in English child data, lasting for a very limited time (about a week), cf. examples (29) and (30).

(29) What **means that**? (Roeper 1999: 175)

(30) What **calls that**?

Assuming that this child has learned inversion with *be* (since this is an early acquisition, cf. above), the interesting issue here is that overgeneralization does not affect a major category (all verbs), but only takes place across a class or subcategory. That is, both *mean* and *call* are semantically similar to *be*, belonging to the class of equative verbs, and are therefore affected by this short-lived overgeneralization. Inversion with *mean* has also been found in data from other English-speaking children (Westergaard & Bentzen 2010; Westergaard forthcoming). An obvious advantage of this minor type of overgeneralization is that is reduces the need for "unlearning" in the language acquisition process.

## 7. Conclusion

In this paper, I have reviewed some early acquisition data where children are exposed to variation in the input, showing that young children are conservative learners, typically not (over-)generalizing across major categories. Such findings are difficult to explain in traditional parametric accounts of language acquisition, including theories of grammar competition. In the model of micro-cues, the acquisition data are accounted for in the following way: Children are endowed with a UG consisting of syntactic primitives and principles of structure building, which enables them to parse the input that they are exposed to. In the acquisition process, they build small pieces of abstract syntactic structure, the micro-cues, which become part of their knowledge of a specific language. The acquisition process is a development from specific to more general knowledge, and this development takes place in small steps based on positive evidence in the input, where each step represents the addition of a feature, a sub-category or one or more lexical items.

This ensures that any overgeneralization will also be minor, reducing the need for unlearning. The acquisition process is also affected by a principle of economy, accounting for the general lack of errors of commission in child language data.

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## *Author's address*

Marit Westergaard
UiT The Arctic University of Norway
Department of Language and Linguistics
P.O. Box 6050 Langnes
9037 Tromsø
Norway

marit.westergaard@uit.no

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# Self-Determination, Self-Regulation, and the Brain: Autonomy Improves Performance by Enhancing Neuroaffective Responsiveness to Self-Regulation Failure

Lisa Legault and Michael Inzlicht
University of Toronto

The importance of autonomous motivation in improving self-regulation has been a focal topic of motivation research for almost 3 decades. Despite this extensive research, however, there has not yet been a mechanistic account of *how* autonomous motivation works to boost self-regulatory functioning. To address this issue, we examined the role of autonomy in 2 basic self-regulation tasks while recording a neural signal of self-regulation failure (i.e., the error-related negativity; ERN). Based on the notion that autonomy improves self-regulation, we anticipated that autonomous motivation would enhance neuroaffective responsiveness to self-regulatory failure and thus improve performance relative to controlled motivation. In Study 1 ($N$ = 43), we found that trait autonomy was positively associated with self-regulatory performance and that this effect was mediated by increased brain-based sensitivity to self-regulation failure, as demonstrated by a larger ERN. Study 2 ($N$ = 55) replicated and extended this pattern using an experimental manipulation of autonomy; when autonomous motivation was contextually supported, task performance increased relative to those for whom autonomy was undermined and those in a neutral condition. In addition, this effect was mediated by both increased perceptions of autonomy and larger ERN amplitudes. These findings offer deeper insight into the links among motivational orientation, brain-based performance monitoring, and self-regulation.

*Keywords:* autonomy, motivation, self-regulation, error-related negativity, performance monitoring



Human autonomy plays a pivotal role in self-regulation and performance. Whatever the behavioral domain, feelings of engagement, diligence, and vitality are higher when the motivation underlying a goal or behavior is autonomous or self-endorsed rather than pressured or controlled. As a result, goal-related performance tends to be better. Researchers attribute the effect of autonomy on goal-regulation to the fact that autonomy represents volition and cohesion in action. In other words, feelings of choice, interest, deep personal relevance, and internal causality underlie the experience of autonomous behavior, which energizes and sustains goal-striving.

This explanation, however, does not address the precise mechanism responsible for the self-regulatory or goal-related benefits of autonomy. Although many studies in social, personality, and motivational psychology have noted that autonomy is critical to good self-regulation, little is known about why, exactly, autonomy leads to better self-regulation. Therefore, we seek a deeper understanding of the effect of autonomy on self-regulatory performance. By inspecting the neural mechanisms that link autonomy to self-regulatory performance, we hope to illustrate *why* autonomous motivation is more effective and efficient than other forms of motivation. More specifically, we assess error-related brain activity in order to test whether autonomy improves performance by promoting receptivity to instances when self-regulation should be improved.

## Self-Regulation and Self-Determination Theory

The ability to control and restrain automatic impulses and habits in the service of goal attainment is the oft-cited crux of self-regulation (cf. self-control; Barkley, 1997; Miyake et al., 2000), but it also refers more generally to the many processes individuals use to manage behavior, thoughts, and emotions (Fujita, 2011). It is, therefore, an extremely important executive function and, indeed, one of the defining features of human behavior (Baumeister, Heatherton, & Tice, 1994; Damasio, 1994). Moreover, the failure of self-regulation is one of the central problems of the human condition. For instance, deficits in self-regulation are found in a large number of psychological disorders including attention-deficit/hyperactivity disorder [ADHD], antisocial personality disorder, borderline personality disorder, addiction, eating disorders, and impulse control disorders (Barkley, 1997; Pierce & Cheney, 2004). In contrast, good self-regulators—those who can aptly manage the circumstances and impulses that obstruct goal attainment—are happier, healthier, and more productive (e.g., Tangney, Baumeister, & Boone, 2004).

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Lisa Legault and Michael Inzlicht, Psychology Department, University of Toronto, Toronto, Ontario, Canada.

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Correspondence concerning this article should be addressed to Lisa Legault, who is now at the Department of Psychology, Clarkson University, 8 Clarkson Avenue, Potsdam, NY 13699-5825. E-mail: llegault@clarkson.edu

Given the importance of self-regulation to adjustment and performance, it becomes important to understand the ways in which it can be enhanced. As it turns out, cultivating the right kind of motivation can help increase self-regulatory capacity and success. For example, if an individual is attempting to regulate his or her diet or trying to quit smoking, the reasons she or he draws upon to substantiate his or her self-regulatory effort can influence whether goal-regulation is successful or not (Muraven, Gagné, & Rosman, 2008). Indeed, 3 decades of research in self-determination theory (SDT) indicate that when motivation underlying regulatory efforts is autonomous and self-driven, rather than externally controlled, goal achievement is more likely (Deci & Ryan, 1985b, 2002, 2008).

## The Role of Autonomy in Self-Regulatory Performance

Self-determination theory suggests that autonomous motivation is an effective means to self-regulation because it is initiated and guided by choices that cohere with one's needs, values, and self-selected aspirations. Similarly, autonomously functioning individuals seek out choices and self-direction, feeling generally free of interpersonal coercion. For instance, an autonomously motivated high school student might complete his or her homework every night after school because she or he finds the work to be enjoyable and interesting (i.e., intrinsic motivation) or because she or he believes it is an important aspect of learning (i.e., personally endorsed value). In order to encourage autonomy, autonomy-supportive environments offer choice, enhance interest, and support inner motivational resources. In contrast, individuals with a controlled motivational orientation look to external prompts and controls to determine their behavior and experience their environment as restrictive. Accordingly, controlling environments use pressure, threat, and contingent regard to extract prescribed thinking and behavior, which undermines autonomy and promotes controlled motivation. To continue with the academic example, a controlled student might complete his or her homework because his or her parents require him or her to do so, or solely for the purpose of obtaining a desired grade.

Of central relevance to the current study is the finding that autonomy improves self-regulatory performance. Thus, because autonomous motivation is self-concordant, reflecting what a person truly desires, values, or finds interesting, it is associated with better self-regulatory success, compared to controlled forms of motivation. In the academic domain, for instance, autonomously motivated students study harder, pay more attention in class, ask more questions, and get better grades (Guay, Ratelle, & Chanel, 2008; Reeve, Bolt, & Cai, 1999; Sheldon & Elliot, 1998; Vallerand, Fortier, & Guay, 1997; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). They also show enhanced cognitive flexibility, conceptual understanding, and active information processing (Grolnick & Ryan, 1987). In the health regulation domain, autonomous motivation leads to superior self-regulation in weight loss and weight loss maintenance (Teixeira et al., 2010; Williams, Grow, Freedman, Ryan, & Deci, 1996), as well as in smoking cessation (Williams et al., 2006; Williams, Niemiec, Patrick, Ryan, & Deci, 2009), alcohol abstinence (Ryan, Plant, & O'Malley, 1995), and diabetes management (Williams, Patrick, et al., 2009). In the domain of environmental behavior, autonomous motivation toward the environment has been shown to predict greater success in the achievement of personal environmental goals over the course of a 7-day assessment period (Osbaldiston & Sheldon, 2003). Autonomy also appears to play an important role in long-term persistence in sports (Pelletier, Fortier, Vallerand, & Brière, 2001), as well as persistence and problem solving on cognitive tasks (Moller, Deci, & Ryan, 2006).

Additional work suggests that when the social context supports autonomy by offering choices and promoting interest, autonomous motivation increases, and cognitive control is thus enhanced, including improved thought suppression and delay of gratification (Muraven et al., 2008), as well as increased concentration (Bernier, Carlson, & Whipple, 2010; Muraven et al., 2008) and superior inhibition of implicit biases (Legault, Green-Demers, Grant, & Chung, 2007; Legault, Gutsell, & Inzlicht, 2011). These studies are important in demonstrating that autonomous motivation (and the support thereof) is likely to boost both cognitive and behavioral performance.

Despite the abundance of work indicating that autonomy improves self-regulation and goal-related performance, a basic and mechanistic understanding of this effect is currently absent. That is, we do not really understand why autonomy improves performance on tasks and behaviors requiring self-regulation. Until now, the "mechanisms" used to explain the relative effectiveness of autonomous regulation over controlled regulation suggest that autonomy fosters relatively more energy (Muraven et al., 2008; Ryan & Deci, 2008) and automaticity (Legault, Green-Demers, & Eadie, 2009) during self-regulatory pursuits. However, these explanations do not delineate a clear process through which autonomy exerts its benefits. That is, they do not provide an explanation of *how* autonomy affects the processing of information and the monitoring and correcting of behavior in the service of optimal performance. Like previous motivation researchers, we propose that autonomy fosters superior behavioral performance through better cognitive control. However, we go a step further by proposing a mechanism for this effect. Specifically, we suggest that autonomy bolsters self-regulation by amplifying brain-based sensitivity to self-regulation failure.

## Autonomy and Performance: The Mediating Role of Error Sensitivity

Because autonomy facilitates goal directed behavior and protects against self-regulatory depletion (Moller et al., 2006; Muraven, 2008; see Inzlicht & Schmeichel, in press), it follows that it might also promote more adaptive responses to self-regulatory errors and failures—responses that might in fact enhance further performance and goal pursuit. Autonomy promotes behavioral persistence in a wide variety of contexts that require continuous self-regulation over extended periods of time (e.g., studying, dieting, exercising, quitting smoking, etc.). This constant self-regulatory effort and attention makes failure (and its accompanying distress) unavoidable. Considering the high probability of self-regulatory failures, errors, and setbacks in any domain requiring cognitive, affective, and behavioral control, it becomes clear that adaptive responding and behavioral adjustment following such failures is important in minimizing further errors and in predicting the success of future performance (Rabbitt & Rodgers, 1977). Successful self-regulation, in other words, requires that people notice, orient, and react to errors when they occur, so that they can learn from them and thus minimize future instances of them (Holroyd & Coles, 2002). Therefore, we propose that autonomy enhances self-regulatory performance because it encourages receptivity to self-regulation failures.

Why should autonomy promote such responsiveness to errors? Two fundamental components of autonomous functioning are the acceptance of negative affect (Reeve, 2009) and nondefensiveness to threatening self-relevant information (Hodgins & Knee, 2002; Hodgins et al., 2010). As such, we theorize that errors, failures, and negative feedback should be attended to in a receptive and responsive manner when the motivation underlying behavior is autonomous. Indeed, past research has shown that when people are autonomously motivated, they are less defensive and ego-protective and tend to openly acknowledge negative affect, criticism, and personal shortcomings (Hodgins & Liebeskind, 2003; Weinstein et al., 2011). Controlled motivation, on the other hand, is associated with increased defensiveness and denial in response to threatening self-relevant information (Hodgins et al., 2010). In line with these findings, we suggest that autonomy increases vigilance in performance monitoring by promoting awareness of error-related distress. Because personal errors are not affect-neutral events (quite the contrary, they alert us that goal attainment is in jeopardy) and because autonomy promotes deep and mindful engagement in action, it follows that feelings of autonomy should increase attention and emotional reactivity to those moments when self-regulation efforts have failed. This "caring about" one's mistakes is a key adaptation to the environment that allows people to slow down, recalibrate their behavior, and ultimately improve their performance. Here, we examine whether autonomy enhances performance by augmenting reactivity to self-regulation failures at the level of the brain.

## The ERN: A Distress Signal of Self-Regulation Failure

Self-regulation involves a cognitive and affective system that is supported by specific brain areas and that facilitates optimal performance through its ability to plan, think flexibly and abstractly, acquire rules, attend selectively, initiate appropriate behavior, and inhibit inappropriate behavior. Based on cybernetic feedback-loop theories of self-regulation (e.g., Wiener, 1948), psychological and neuroscientific models of self-regulation suggest that two complementary systems are necessary to perform these various functions. In social and personality psychology, for instance, Carver and Scheier (1981) have described a "test" process that continually compares current behavior with ideal criteria, which then signals the "operating" process to elicit change toward a desired end. Similarly, Wegner (1994) has discussed the dual-action of a monitoring process, which scans for lapses in self-control, and an operating process, which acts to rectify any self-control failure. Although both monitoring and operating systems are important, the monitoring system is especially critical because it determines when self-control needs to be initiated. One of the best known neural correlates of self-control in general, and the monitoring system in particular, is the error-related negativity (ERN; Falkenstein, Hohnsbein, & Hoormann, 1991; Gehring, Goss, Coles, & Meyer, 1993).

The ERN is an event related potential (ERP) that is characterized by a pronounced negative deflection on electroencephalography (EEG) that occurs within 100 ms of making an error on a task and is thought to be generated by the anterior cingulate cortex (ACC; Dehaene, Posner, & Tucker, 1994). Holroyd and Coles (2002) have suggested that the ERN reflects an error detection system that monitors performance and detects incongruity between intended and actual responses (see also Yeung, Botvinick, & Cohen, 2004). This process is implemented in the ACC (Kerns et al., 2004)—a brain structure that connects to both limbic and prefrontal regions of the brain and is attuned to response conflict, negative affect, errors, uncertainty, and psychological pain (Bush, Luu, & Poser, 2000; Ridderinkhof, Ulsperger, Crone, & Nieuwenhuis, 2004; Shackman et al., 2011).

Another view of the ERN suggests that, rather than simply reflecting attention to errors or discrepancies between desired and actual responses, the ERN is in fact linked to motivational and affective responses to such errors (Bartholow, Henry, Lust, Saults, & Wood, 2012; Hajcak & Foti, 2008; Hajcak, McDonald, & Simons, 2003; Inzlicht & Al-Khindi, 2012; Luu, Collins, & Tucker, 2000). Indeed, it has been suggested that the ERN might partially reflect a "distress signal" when performance is worse than expected (Bartholow et al., 2005, p. 41). This perspective asserts that ERN magnitude is associated with the value placed on errors and that increased motivation will amplify the ERN (Weinberg, Riesel, & Hajcak, 2012). Extending this recent motivational view, we suggest that the quality—and not just the quantity—of motivation matters when it comes to enhancing the ERN. That is, autonomous motivation is expected to be related to the degree to which performance is monitored and improved. Because feelings of autonomy promote acknowledgment of negative affect (rather than denial or suppression), as well as the integration of mistakes and personal faults (e.g., Weinstein et al., 2011), autonomous motivation should predict sensitivity to errors in performance. To the extent that the ERN reflects such an affective response to errors, autonomous motivation should enhance the ERN.

## The Role of Autonomy in the ERN

Although some recent research has examined patterns of brain activation associated with autonomous and controlled motivation in general (see Murayama, Matsumoto, Izuma, & Matsumoto, 2010; as well as Lee & Reeve, 2012), knowledge of the brain-mediated mechanisms through which autonomy influences self-regulation processes is limited. Only two correlational studies (in the domains of prejudice regulation and education) have implied a link between autonomous motivation and the ERN. Specifically, it has been suggested that those who display more personal reasons for inhibiting prejudice demonstrate increased ERN amplitude when failing to suppress bias relative to those with more external reasons (Amodio, Devine, & Harmon-Jones, 2008). Additionally, intrinsic academic motivation among 3rd to 5th graders has been correlated with larger ERNs (Fisher, Marshall, & Nanayakkara, 2009). Although these studies suggest that autonomy is related to increased neural responding to self-regulation errors, the link between general autonomy and brain-mediated self-regulation is unknown. More importantly, we are not aware of any studies that have examined how experimental changes in autonomy might impact the brain bases of self-regulation on performance tasks. Therefore, to fill this gap and provide a more complete picture of the link between autonomy and performance, we assess how brain-implemented performance monitoring relates to trait differences in autonomy as well as how it may be affected by experimental manipulations of autonomy. By increasing our understanding of the neurophysiological processes that mediate autonomy's impact on self-regulation, we can join recent work (i.e., Lee & Reeve, 2012; Murayama et al., 2010) in shedding much-needed light on the neural bases of self-determination and offer additional validation of the real, far-reaching difference between autonomous and controlled motivation.

## Overview of Studies

Our goal was to understand how autonomous motivation enhances performance-based self-regulation. To do so, we assessed performance monitoring in the anterior cingulate cortex during two tasks requiring self-regulation. In Study 1, we examined associations among trait autonomy, self-regulatory performance, and neuroaffective responses to self-regulation failure (i.e., the ERN). In Study 2, we assessed the impact of state manipulations of autonomy on self-regulation and the ERN. We expected that both trait autonomy and state-induced autonomy would increase performance on the self-regulation task (i.e., by reducing the number of performance errors) and that this effect would be mediated by the heightened neuroaffective responding to those errors, that is, larger ERNs.

## Study 1

### Method

**Participants and procedure.** In exchange for course credit, 43 participants (28 women) from the University of Toronto Scarborough were invited to complete a computer task while brain activity was recorded. Participants' age ranged from 18 to 30 ($M$ = 19.3 years; $SD$ = 1.97). Before electrophysiological recording, participants were asked to complete a trait measure of motivational orientation.

**Measures.**

***Trait motivational orientation.*** Individual differences in motivational orientation were assessed using the General Causality Orientation Scale (GCOS; Deci & Ryan, 1985a). The GCOS consists of 12 vignettes describing interpersonal scenarios, followed by a list of responses that represent either an autonomous (12 items), controlled (12 items), or impersonal/helpless orientation (i.e., an absence of motivation; 12 items). These dimensions are thought to represent relatively enduring aspects of personality. Items reflecting an autonomous orientation illustrate a preference for interest-enhancing and optimally challenging situations and a tendency to interpret social contexts as autonomy-supportive rather than controlling or imposing. In contrast, the controlled orientation assesses the extent to which a person is oriented toward being controlled by rewards, deadlines, structures, ego-involvements, and the directives of others. The impersonal orientation taps personal ineffectiveness and a general lack of motivation. Such individuals are likely to believe that attaining desired outcomes is beyond their control and that achievement is largely a matter of luck or fate. An example item from the GCOS asks respondents to rate on a 7-point scale "the most important consideration when embarking on a new career." The autonomous orientation item states, "How interested I am in that kind of work"; the controlled orientation item states, "Whether there are good possibilities for advancement"; and the impersonal orientation item states, "Whether I could do the work without getting in over my head." Internal consistency was $\alpha$ = .77 for the autonomous motivation subscale; $\alpha$ = .72 for the controlled motivation subscale, and $\alpha$ = .74 for the impersonal (i.e., no motivation) subscale.

***The go/no-go task.*** After completing the GCOS, participants performed the Go/No-Go task, which served as the main behavioral indicator of self-regulatory performance. Stimuli consisted of the letter $M$ (the "Go" stimulus) and the letter $W$ (the "No-Go" stimulus). Participants were required to press a button when the "Go" stimulus appeared and to refrain from pressing the same button when the "No-Go" stimulus appeared. Each trial consisted of a fixation cross ("+") presented for 500 ms, followed by either a "Go" or "No-Go" stimulus for 100 ms. The maximum time allowed for a response was 500 ms, and the intertrial interval was 50 ms. Participants first completed a practice block and then completed six experimental blocks, each consisting of 40 "Go" trials and 20 "No-Go" trials (presented randomly). The performance score was based on errors of commission (going on a No-Go trial) rather than the incongruency effect because there is no latency-based response for correct No-Go trials (that is, the correct response is no response), and thus it is not possible to generate incongruency effects for the Go/No-Go task.[1] Moreover, we stressed accuracy rather than speed by encouraging participants to respond as accurately as possible. It should also be noted that this task indeed required self-control. That is, because "Go" was the dominant trial type, "going" (i.e., pushing the button) became the dominant response. Thus, "No-Go" trials required self-regulation since participants had to suppress or inhibit their prepotent response to press the "Go" button.

Finally, a primary behavioral indicator of posterror adjustment, namely, posterror slowing (PES), was calculated. PES refers to the prolonged reaction time (RT) on trials following an error compared to RTs following correct trials (Rabbitt, 1966) and is thought to reflect the recruitment of executive control resources in the service of correcting performance. PES was computed as the difference in reaction time for correct responses following correct trials versus correct responses following incorrect trials.

***Neurophysiological recording.*** Continuous EEG during the Go/No-Go task was recorded using a stretch Lycra cap embedded with 32 tin electrodes (Electro-Cap International, Eaton, Ohio). Recordings were digitized at 512 Hz using Advanced Source Analysis (ASA) acquisition software (Advanced Neuro Technology B.V., Enschede, the Netherlands) with average-ear reference

[1] No-go errors (i.e., "going" when instructed not to) were used as the basis for both ERN and performance analyses, rather than go errors (i.e., "not going" when instructed to "go"), as it is not possible or appropriate to generate an ERN for go errors. Go errors are errors of omission and thus they do not produce a button-press response. As we have discussed, ERNs must be locked to a response. For this same reason, ERP response negativity in response to correct trials (see Figure 1) was also locked to correct go trials rather than correct no-go trials. For the sake of completeness, however, we include associations between motivation and go errors here. Autonomy was negatively associated with making go errors, $r(42) = -.38$, $p < .01$, whereas neither controlled nor impersonal orientations were associated with go errors.

and forehead ground. EEG was corrected for vertical electrooculogram artifacts (Gratton, Coles, & Donchin, 1983) and digitally filtered offline between 0.1 and 15 Hz (fast Fourier transform implemented, zero phase-shift Butterworth filter). Epochs were defined as 200 ms prior to and 800 ms subsequent to response. The EEG signal was baseline-corrected by subtracting the average voltage during the 200 ms time period prior to the response. Artifacts were automatically detected with $-75$ μV and $+75$ μV thresholds. Data for these epochs were averaged within participants independently for correct and incorrect trials and then grand-averaged within the respective conditions. The ERN was defined as the minimum peak deflection occurring between 50 ms preresponse and 150 ms postresponse at the frontocentral midline electrode (FCz). ERNs were based on no fewer than six artifact-free error trials (Olvet & Hajcak, 2009b).

## Results and Discussion

We hypothesized that trait autonomy would be positively related to both task performance (i.e., self-regulatory effectiveness) and brain-based error monitoring. Thus, as autonomous motivation increased, we anticipated that ERN amplitude would increase and errors would decrease. In addition, we anticipated that error monitoring would mediate the association between autonomy and performance. Finally, we expected that neither controlled nor impersonal motivation would be associated with error monitoring or performance, thereby providing evidence that it is the quality—and not simply the quantity—of motivation that really matters.

**Autonomous motivation and self-regulation.** The pattern of correlations (see Table 1) suggested that as autonomous motivation increased, so did performance (as measured by number of errors of commission), $r(42) = -.35$, $p < .05$, and ERN amplitude, $r(42) = -.38$, $p < .01$ (see Figure 1 for a scatterplot of autonomy and the ERN). In turn, the ERN was correlated with number of performance errors, $r(42) = .34$, $p < .05$. An examination of partial correlations ensured that, even after controlling for the possible effect of error rate, a significant association between autonomy and the ERN remained, $r(42) = -.30$, $p < .05$. Moreover, we assessed correlations between the correct related negativity (CRN; the neurophysiological response to making a correct response) and the remaining variables. Importantly, this pattern of results revealed that the CRN was unrelated to performance and not significantly related to autonomy. This finding suggests that effects of the ERN, as a function of autonomy, are specifically related to error processing rather than performance monitoring, more generally. To further underscore this point, we assessed correlations between the ERN difference score (i.e., ERN–CRN) and related variables. This "difference wave" approach is important because it allows us to cancel out processes common to all performance monitoring and to specifically isolate our variable of interest, error processing (Luck, 2005). The pattern of associations for the ERN remained intact (see Table 1). Figure 2 illustrates ERN and CRN as a function of high and low trait autonomy.

Dipole source localization confirmed that the ERNs were generated in an area consistent with the ACC. That is, coordinates of the preauricular-nasion (in millimeters) were $x = 0.1$, $y = 0.1$, $z = 60.0$; dipole strength was 65.48 nAm, and this source accounted for 84.1% of the variance of the signal.

We next examined the process via which autonomous motivational orientation predicted improvements in self-regulatory performance. The mediating effect of the ERN on the link between autonomy and performance was ascertained using the bootstrap method outlined by Preacher and Hayes (2004, 2008). Again, we used the ERN–CRN difference score in this analysis, to hone in on error processing (Luck, 2005). Results are presented in Figure 3. First, as noted above, an analysis of behavioral performance revealed that autonomy was negatively related to number of errors on the Go/No-Go, $t(42) = -2.41$, $p < .05$. Second, as autonomy increased, so did ERN difference scores, $t(42) = -2.27$, $p < .05$, with more autonomy associated with higher (more negative) ERN difference scores. Third, after controlling for autonomy, the ERN difference score significantly predicted task performance, $t(42) = 2.34$, $p < .05$. To ascertain the indirect effect, percentile-based bootstrap confidence intervals (CI) and bootstrap estimates of standard errors were generated based on 5,000 bootstrap samples. The indirect effect was reliable, $M = -.18$ ($SE = .09$), 95% bootstrap CI = $-.40$ to $-.03$, suggesting that the ERN mediates the link between autonomy and performance on the self-regulation task.

Inspection of behavioral posterror adaptations revealed that, although autonomy was weakly associated with posterror slowing ($\beta = .18$), this link was not significant ($p = .25$). Given that past research has failed to find group differences in posterror slowing on the Go/No-Go task (e.g., Inzlicht & Al-Khindi, 2012), this

Table 1
*Descriptive Statistics and Pearson Correlations for Main Variables in Study 1*

| | *M* | *SD* | Commission errors | Omission errors | ERN | CRN | ERN–CRN | PES |
|---|---|---|---|---|---|---|---|---|
| Autonomy (trait) | 5.41 | 0.66 | $-.35^{*}$ | $-.38^{**}$ | $-.38^{**}$ | −.12 | $-.35^{*}$ | .18 |
| Commission errors | 14.47 | 10.61 | — | $.53^{**}$ | $.34^{*}$ | .02 | $.43^{**}$ | $-.32^{*}$ |
| Omission errors | 3.64 | 4.51 | | — | $.28^{\dagger}$ | −.12 | $.40^{**}$ | −.06 |
| ERN | −6.66 | 4.57 | | | — | $.50^{**}$ | $.87^{**}$ | −.17 |
| CRN | −3.36 | 2.28 | | | | — | −.07 | −.20 |
| ERN–CRN | −3.31 | 3.87 | | | | | — | −.09 |
| PES | 63.74 | 50.41 | | | | | | — |

*Note.* Theoretical range for trait autonomy is 1–7. The ERN, CRN, and ERN-CRN are scored negatively, as they represent negative-going waveforms; thus, more negative scores represent greater ERP amplitude. ERN = error-related negativity; CRN = correct related negativity; ERP = event-related potential; PES = posterror slowing.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

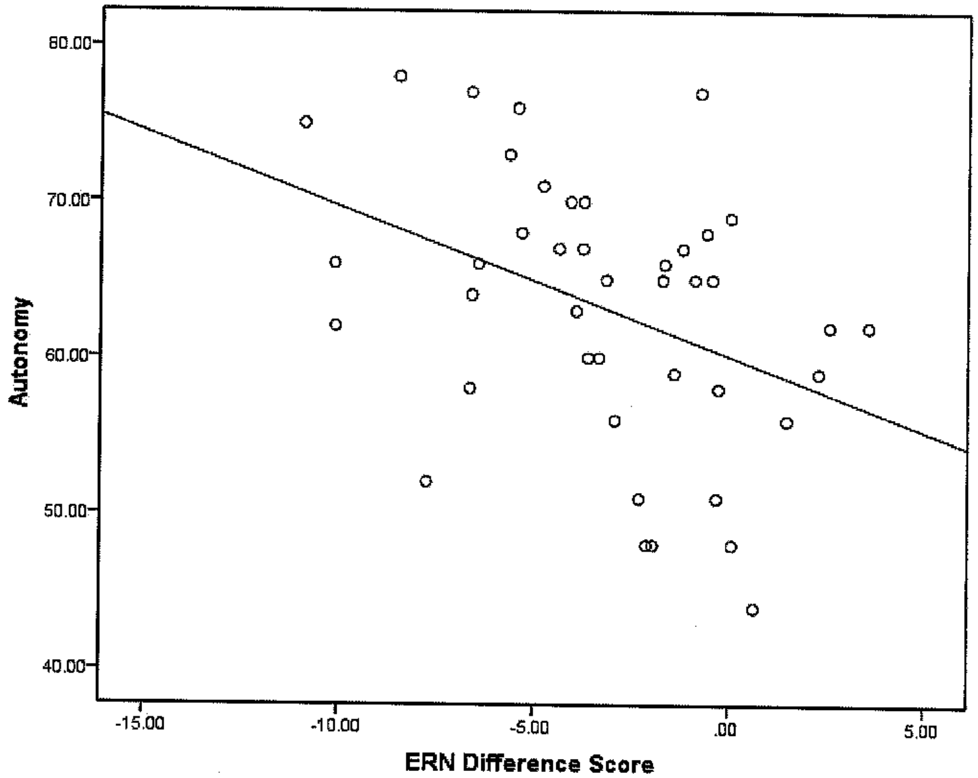


*Figure 1.* Scatterplot of autonomy and the ERN (Study 1). ERN = error-related negativity.

result is not entirely surprising (we revisit this issue in Study 2 using a different task and a direct induction of autonomy). See Table 1 for descriptive statistics for posterror slowing.

**Controlled motivation and self-regulation.** We also examined associations between controlled motivational orientation, on one hand, and performance and error monitoring, on the other. The assessment of this relationship is important because previous work has suggested that general motivational magnitude is associated with the ERN (e.g., Weinberg, et al., 2012). However, we propose that it is the quality—rather than simply the quantity—of motivation that boosts self-regulation by enhancing error detection. In support of our expectation, controlled motivation was not significantly associated with performance errors, $r(42) = .12$ (*ns*), nor the ERN, $r(42) = -.17$ (*ns*). Interestingly, although it did not quite reach significance, the association between impersonal orientation (i.e., those showing a lack of motivation) and the ERN showed the opposite pattern compared to the two types of motivation, $r(42) = .23$, $p = .16$, suggesting that as motivation diminishes, the ERN does as well. Like controlled motivation, impersonal orientation was not significantly related to performance, $r(42) = .10$ (*ns*).

In sum, these findings suggest that autonomous motivation is significantly related to error processing, which serves to increase self-regulation. In contrast, the association between controlled motivation and error processing was negligible, suggesting that controlled motivation is not a sufficient predictor of the ERN. Rather, the source of motivation (i.e., autonomous vs. controlled) is important in understanding the neural mechanism of self-regulation. These results lend support to the idea that the quality of motivation (and not just the quantity) is a significant factor in signaling when self-regulation has failed (but not necessarily when it has succeeded!).

## Study 2

Study 2 sought to extend Study 1 in various ways. First, rather than measure trait autonomy, we used an experimental induction of autonomy to test the causal impact of autonomous motivation on self-regulatory performance. According to self-determination theory, autonomous motivation is multifaceted and can be enhanced in various ways. That is, the following situations are said to be autonomy-supportive: the provision of choice; the promotion of interest and intrinsic motivation, the support of inner motivational resources, the provision of optimal challenge, and the administration of informational feedback and structure. In contrast, controlling environments override autonomy and instead induce motivation by emphasizing external demands. In line with this reasoning, we either supported autonomy toward a task (i.e., by enhancing choice and interest, which are key means through which to target autonomy) or exerted external control over completion of the task.

Second, we used a different measure of self-regulatory capacity, the Stroop task, to verify the robustness of the effect. Indeed, it may be argued that the Go/No-Go and the Stroop assess different dimensions of self-regulation. That is, because the Go/No-Go requires the ability to keep changes in task instruction online (i.e., "No-Go" vs. "Go"), it taps into the switching component of self-regulation. The Stroop, on the other hand, is a canonical test of inhibitory control. Compared to the Go/No-Go, which establishes prepotent responding by presenting twice as many Go trials

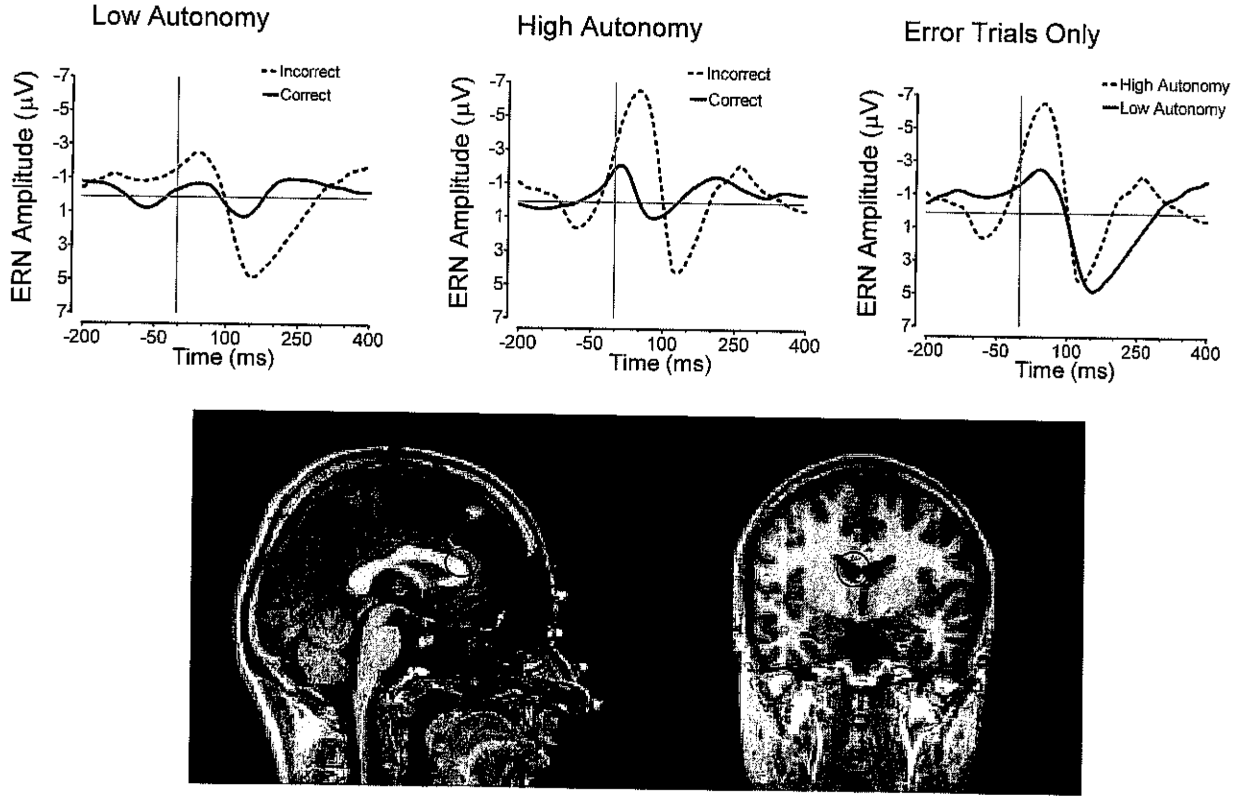


*Figure 2.* Differences in the ERN as a function of trait autonomy (median split). ERN = error-related negativity.

as No-Go trials (thus, "going" becomes the dominant response because it is more frequent), the Stroop entails a more deeply entrenched prepotent response tendency (i.e., reading) that may be more difficult to override. In other words, for the Go/No-Go, inhibitory control involves the stopping of a habitualized motor response. Conversely, the Stroop assesses inhibition of the prepotent response to read the visual presentation of words. Because reading is automatic and well-learned, the dominant response is to read the text presented rather than to respond to other physical characteristics of the text (e.g., naming the color of the ink with which the word is written). Thus, although both tasks represent self-regulatory ability, they are somewhat different in the degree to which they assess inhibition and switching capacities. Finally, in addition to assessing the mediating effect of the ERN in the association between autonomy-support and performance, we also examined the intervening role of intrinsic task motivation and perceived task value—two key features of autonomous motivation.

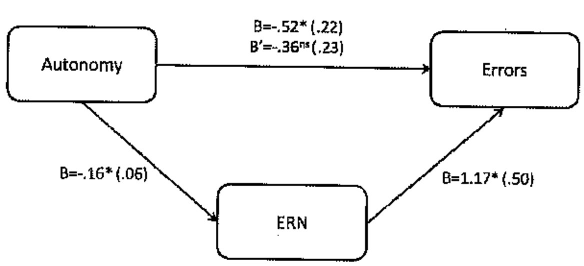


*Figure 3.* The mediating role of error monitoring in the link between autonomy and performance (Study 1). Unstandardized regression coefficients are presented. ERN is operationalized as the ERN–CRN difference score. ERN = error-related negativity; CRN = correct related negativity; ns = not significant. * $p < .05$.

## Method

**Participants and procedure.** Fifty-five undergraduates (29 male)[2] at the University of Toronto Scarborough participated for either course credit or $15.00 compensation. Participants' age ranged from 18 to 30 years ($M$ = 19.6 years; $SD$ = 2.03). Participants were invited to complete a study titled "Brain Games," wherein they performed a computer task while EEG was recorded. In order to manipulate autonomous and controlled motivation, participants were randomly assigned to one of three conditions (i.e., autonomy-supportive, controlling, or neutral). Our experimental manipulation was based on the notion that the enhancement of choice and interest increases autonomous motivation, whereas the administration of pressure and requirement thwarts it (Deci & Ryan, 2000, 2008; Moller et al., 2006).

[2] One reason why slightly smaller sample sizes tend to have sufficient power to detect motivational and affective effects on the ERN (e.g., Amodio et al., 2008; Fisher et al., 2009; Gonsalkorale, Sherman, Allen, Klauer, & Amodio, 2011) is because the ERN is a highly reliable and stable measure (Olvet & Hajcak, 2009a, 2009b; Weinberg & Hajcak, 2011).

Participants in the two experimental conditions (i.e., the autonomy-supportive and controlling conditions) read a descriptive list of four computer tasks (i.e., "brain games") These games included (a) The Mental Distraction Game; (b) A Game of Accuracy; c) Ignore Your Impulses, and (d) Cognitive Response Latency Test. Unbeknownst to participants, each selection described the same task (i.e., the Stroop task) in a unique way. Participants in the autonomy-supportive condition ($n = 18$) were instructed to select the game they most wanted to perform and were then directed toward the task (which was always the Stroop task). It is worth noting that we attempted to tap into choice (directly) and interest (indirectly) in the autonomy induction because both are key experiences in autonomous motivation. In the controlled condition, participants ($n = 18$) saw the list of choices but were pressured by the experimenter (who was unaware of the nature and purpose of the study) to perform task *d* (i.e., the Cognitive Response Latency Test). In the neutral condition ($n = 19$), participants went directly to the Stroop task, without being presented with a list of choices. After completion of the Stroop, various motivational variables were assessed.

**Measures.**

***Stroop task.*** The main behavioral measure was performance on a color-naming Stroop task (MacLeod, 1991). This task, which lasted about 20 min, consisted of color words (i.e., red, green, blue, and yellow), each of which was presented in a color that either matched (congruent) or did not match (incongruent) the written meaning of the word. Self-regulation is required on incongruent trials in order to correctly identify the color of the ink with which the word is printed and to inhibit prepotent responding to the semantic meaning of the word. Responses were measured by having participants press a corresponding color button on a response box. In each trial, a fixation cross ("+") appeared for 500 ms, followed by the stimulus word presented for 200 ms. Participants were given 800 ms in which to respond. The task contained 10 blocks, each consisting of 32 congruent trials (i.e., the baseline response, e.g., the word "yellow" in yellow ink) and 16 incongruent trials (e.g., the word "yellow" in blue ink). An incongruency effect was calculated by subtracting reaction times on correct congruent trials from reaction times on correct incongruent trials. Performance was calculated by tallying the number of errors on incongruent trials (i.e., the self-regulation trials). We used incongruent errors as the main measure of performance to remain consistent with Study 1 and because we emphasized accuracy on the task, rather than speed. As in Study 1, posterror slowing was also calculated.

***Neurophysiological recording.*** EEG during the Stroop task was recorded and processed according to the technique outlined in Study 1.

***Self-determined task motivation.*** Self-determined motivation toward the Stroop task was measured using the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989; Ryan, 1982). That is, we measured three key constituents of autonomous motivation toward the Stroop task, including *perceived choice*, *task interest/enjoyment*, and *task value/usefulness*. Perceived choice assessed the extent to which participants felt as though they freely chose to do the task (four items; e.g., "I felt like it was my choice to do this task"; $\alpha = .75$). The interest/enjoyment scale reflected intrinsic motivation toward the task (four items; e.g., "I enjoyed doing this computer task very much"; $\alpha = .89$), and the value/usefulness dimension tapped the extent to which the value of the task had been internalized, or had come to be seen as having some importance (four items; e.g., "I think that doing this activity is useful for improved concentration"; $\alpha = .76$). Correlations among these three dimensions ranged from .53 to .75.

***General task motivation.*** Apart from measuring self-determined motivation, we also assessed other dimensions of motivation toward the Stroop task, in order to verify that any experimental effects could be attributed specifically to changes in autonomous motivation rather than changes in motivation more generally. Moreover, we wanted to ensure that the controlling task instructions did not undermine participants' motivation to complete the task. This check is important because, in order to test whether the ERN can be attributed to motivational quality rather than quantity, we need to verify that both autonomous and controlled motivational inductions increased motivation overall. Thus, although we expected that those in the autonomy-supportive condition would be more autonomously motivated, we nonetheless anticipated that both motivation groups would be *generally motivated to complete the task*. To ascertain dimensions of motivation that are relatively less proximal to autonomy than those tapped by the self-determined task motivation measure (above), we assessed *task confidence* (three items; e.g., "I feel like I would do well on this task in the future"), and *effort exerted* (two items; e.g., "I tried to do well on this task").

## Results and Discussion

We hypothesized that motivational quality, rather than quantity, would predict the degree to which self-regulation failure would be detected and performance enhanced. Specifically, we anticipated that the support of autonomous motivation toward the task would produce better performance and a larger ERN relative to the controlling and neutral conditions. We also expected that the causal relationship between autonomy-support and performance would be reliably mediated by neural responsiveness to self-regulation errors.

**Correlations.** Correlations and descriptive statistics for each variable are presented in Table 2. As in Study 1, inspection of correlations provided preliminary support for our hypotheses. Autonomy (coded: autonomy-supportive = 1; neutral = 0; controlling = −1) was negatively related to performance errors, $r(54) = -.38$, $p < .01$, and associated with more negative ERN amplitudes, $r(54) = -.43$, $p < .01$. In turn, ERN amplitude (negatively scored) was associated with a reduction in performance errors, $r(54) = .45$, $p < .01$. Correlational analyses also revealed that the CRN was unrelated to autonomy and not significantly related to performance. Furthermore, autonomy and performance remained associated with the ERN–CRN difference score. These data describe a pattern of associations that is specific to error processing and not responses in general.

**Self-determined task motivation.** We wanted to verify that that autonomy-supported participants did indeed show increases in self-determined (i.e., autonomous) motivation. An analysis of the self-reported self-determination data supported the causal role of the autonomy manipulation in increasing perceived self-determination toward the task (i.e., feelings of choice, interest, and task value). That is, those in the autonomy-supportive condition experienced greater perceived task choice ($M = 4.38$; $SD = 0.69$)

Table 2
*Descriptive Statistics and Pearson Correlations for Main Variables in Study 2*

| | *M* | *SD* | Self-det. | Incongruent errors | Congruent errors | Incongruent effect | ERN | CRN | ERN–CRN | PES |
|---|---|---|---|---|---|---|---|---|---|---|
| Autonomy (condition) | | | .41** | −.39** | −.40** | −.04 | −.43** | .02 | −.36** | .36** |
| Self-determination | 3.61 | 0.98 | — | −.30* | −.30* | .18 | −.46** | .00 | −.38** | .25† |
| Incongruent errors | 24.98 | 17.09 | | — | .73** | .00 | .45** | .16 | .30* | −.26† |
| Congruent errors | 22.24 | 16.77 | | | — | −.27* | .42** | −.08 | .39** | −.31* |
| Incongruency effect | 77.56 | 59.57 | | | | — | .02 | .20 | −.08 | .00 |
| ERN | −5.33 | 3.38 | | | | | — | .08 | .86** | −.48** |
| CRN | −1.03 | 2.08 | | | | | | — | −.58** | .16 |
| ERN–CRN | −4.30 | 4.04 | | | | | | | — | −.47** |
| PES | 40.18 | 95.83 | | | | | | | | — |

*Note.* Theoretical range for self-determination scores is 1–7. The ERN, CRN, and ERN–CRN are scored negatively, as they represent negative-going waveforms; thus, more negative scores represent greater ERP amplitude. Self-det. = self-determination; ERN = error-related negativity; CRN = correct related negativity; ERP = event-related potential; PES = posterror slowing.
† $p < .10$. * $p < .05$. ** $p < .01$.

than those in the controlling ($M = 3.62$; $SD = 0.62$) and neutral ($M = 3.91$; $SD = 0.60$) conditions, $F(2, 52) = 7.38$, $p < .001$, $\eta_p^2 = .21$. Autonomy-supported participants also reported more interest in the task ($M = 4.25$; $SD = 1.54$), and placed greater value on the task ($M = 4.95$; $SD = 1.32$), compared to controlled ($M_{interest} = 3.30$; $SD = 1.35$; $M_{value} = 3.57$; $SD = 1.03$) and neutral participants ($M_{interest} = 3.16$; $SD = 0.96$; $M_{value} = 3.84$; $SD = 1.07$), $F_{interest}(2, 52) = 4.23$, $p < .05$, $\eta_p^2 = .13$; $F_{value}(2, 52) = 8.22$, $p < .001$, $\eta_p^2 = .22$. These data indicate that the autonomy manipulation exerted its intended effect on various dimensions of perceived autonomy. There were no statistically meaningful differences in perceived self-determination among neutral and controlled participants—although controlled participants felt they had marginally less choice than those not shown the list of task choices (i.e., neutral participants), $F(1, 35) = 2.63$, $p = .11$, $\eta_p^2 = .06$.

**General task motivation.** We also wanted to confirm that, although the autonomy supported group displayed the greatest autonomous task motivation (as shown in the previous paragraph), both motivation groups experienced general motivation toward the task. This check was important to ensure that subsequent effects on the ERN could be attributable to the quality of motivation rather than the quantity. Thus, we analyzed additional dimensions of motivation to ensure that the controlling task instructions did not reduce participants' self-reported level of motivation toward the Stroop task. Supporting the notion that controlled participants showed a general desire to complete the task, results suggested that both controlled ($M = 4.86$; $SD = 1.52$) and autonomy-supported participants ($M = 4.63$; $SD = 1.34$) demonstrated greater confidence in their ability to complete the task than did neutral participants ($M = 3.68$; $SD = 1.34$), $F(1, 35) = 6.85$, $p < .05$, $\eta_p^2 = .15$ (controlled vs. neutral); $F(1, 35) = 4.76$, $p < .05$, $\eta_p^2 = .12$ (autonomous vs. neutral). Indeed, task confidence was similar for autonomy-supported and controlled participants ($F < 1$). This suggests that our manipulation of autonomy and control increased general task motivation relative to the neutral group. A similar pattern emerged for effort exerted on the task, such that controlled ($M = 4.89$; $SD = 0.82$) and autonomy-supported ($M = 4.87$; $SD = 1.23$) participants exerted the same amount of effort on the task ($F < 1$), which was greater than the effort reported by those in the neutral condition ($M = 3.92$; $SD = 0.85$), $F(1, 35) = 13.67$, $p < .001$, $\eta_p^2 = .26$ (controlled vs. neutral); $F(1, 35) = 7.57$, $p < .01$, $\eta_p^2 = .17$ (autonomous v. neutral). These results suggest that the motivational manipulation targeted autonomous motivation specifically and did not exert an undermining effect on general motivation toward the task for those in the controlled condition, as indexed by task confidence and effort.

**Performance.** Behavioral data were assessed using a one-way between-subjects analysis of variance (ANOVA). In line with our expectations, the experimental manipulation exerted an effect on the primary performance variable (i.e., incongruent errors, or Stroop errors), $F(2, 52) = 4.36$, $p < .05$, $\eta_p^2 = .15$. That is, those in the autonomy-supportive condition made fewer Stroop errors ($M = 15.47$; $SD = 10.67$) than those in the neutral condition ($M = 27.16$; $SD = 17.16$) and those in the controlled condition ($M = 30.61$; $SD = 18.42$). Planned contrasts suggested that the support of autonomy reduced Stroop errors relative to those in the neutral group, $F(1, 35) = 7.63$, $p < .01$, $\eta_p^2 = .18$. Autonomy-supported participants also committed substantially fewer Stroop errors than controlled participants, $F(1, 34) = 6.45$, $p < .05$, $\eta_p^2 = .17$. The neutral and controlled participants, however, showed no differences in Stroop errors ($F < 1$). In addition, there were no meaningful group differences in the incongruency reaction time effect, $F < 1$.[3]

We also assessed performance effects for errors on congruent Stroop trials. We analyzed these separately because they are less central to self-control processes but also because the number of congruent and incongruent trials was not equal. Again, the motivational induction demonstrated an overall effect on congruent errors, $F(2, 52) = 5.45$, $p < .01$, $\eta_p^2 = .16$. Specifically, those whose autonomy was supported in the Stroop task made fewer congruent errors ($M = 12.47$; $SD = 9.16$) than those in the neutral ($M = 19.75$; $SD = 14.84$) and controlled conditions ($M = 33.83$;

[3] This lack of effect is not entirely surprising. That is, the incongruency effect is an ambiguous indicator of performance because it may actually reflect greater deliberation during incongruent trials, which can sometimes be associated with better control rather than worse control. Because error rate is a clear indicator of performance, we were principally concerned with errors and not in the incongruency effect. Moreover, we instructed participants to be accurate rather than speedy, thus underscoring the need to focus on error effects.

$SD$ = 32.52). Contrasts revealed that autonomy support reduced errors relative to both the neutral, $F(1, 35) = 3.30$, $p = .08$, $\eta_p^2 = .09$ (marginal effect), and controlled conditions, $F(1, 34) = 6.91$, $p < .05$, $\eta_p^2 = .17$. In addition, controlled participants made marginally more errors than neutral participants, $F(1, 35) = 2.78$, $p = .10$, $\eta_p^2 = .07$.

In sum, these findings reveal that enhancing autonomy in relation to the task exerted a positive effect on task performance. In contrast, increasing external control showed no performance improvement on Stroop errors (as compared to doing nothing to influence task engagement) and actually hindered performance on congruent errors.

**Behavioral adjustment.** As in Study 1, we assessed behavioral adaptation following errors by calculating posterror slowing (PES) in reaction time (i.e., posterror RT minus postcorrect RT). Descriptive statistics and correlations with other variables can be found in Table 2. A one-way ANOVA with PES as the dependent variable revealed an overall effect of motivational condition on PES, $F(2, 52) = 4.62$, $p < .01$, $\eta_p^2 = .14$. Specifically, those whose autonomy was supported in the task showed greater PES ($M$ = 91.08; $SD$ = 136.09) compared to those in the neutral condition ($M$ = 24.89; $SD$ = 35.21), $F(1, 35) = 4.21$, $p = .05$, $\eta_p^2 = .11$, and compared to those who were motivated with controlling tactics ($M$ = 7.95; $SD$ = 71.23), $F(1, 34) = 6.02$, $p = .02$, $\eta_p^2 = .14$ (in fact, controlled participants showed nonsignificant posterror slowing). PES did not differ significantly between the neutral and controlled groups ($F < 1$). These data indicate that the support of autonomy during the Stroop task caused participants to recalibrate their behavior following errors relative to correct trials. This slowing effect underscores the notion that autonomy promotes processing of errors and response conflict, which promotes behavioral correction.

**The ERN.** A 3 (Condition: autonomy-supportive vs. neutral vs. controlling) × 2 (Response: error vs. correct) mixed-factor ANOVA with peak minimum amplitude as the dependent variable was performed. A significant main effect of response revealed that the waveform following error trials (i.e., the ERN) was significantly greater in magnitude ($M$ = −5.33; $SD$ = 3.93) than the waveform following correct trials ($M$ = −1.03; $SD$ = 2.08), $F(1, 52) = 67.33$, $p < .001$, $\eta_p^2 = .56$. In addition, there was a significant main effect of group, $F(2, 52) = 5.14$, $p < .01$, $\eta_p^2 = .17$, indicating that overall the waveform was smaller in the controlling ($M$ = −2.54; $SE$ = 0.41) and neutral ($M$ = −2.68; $SE$ = 0.40) conditions, relative to the autonomy-supportive condition ($M$ = −4.22; $SE$ = 0.41). However, it is important to note that this main effect was qualified by a significant interaction between condition and response type, $F(2, 52) = 4.09$, $p < .05$, $\eta_p^2 = .14$. That is, although the three conditions showed similar amplitudes on correct trials (i.e., the CRN; $F < 1$), the effect of condition on the ERN was significant, $F(2, 52) = 7.71$, $p < .001$, $\eta_p^2 = .23$ (see Figure 4 for an illustration). To be specific, those in the autonomy-supportive condition displayed a larger ERN ($M$ = −7.58; $SD$ = 4.02) than those in the neutral condition ($M$ = −4.57; $SD$ = 2.43), $F(1, 35) = 7.63$, $p < .01$, $\eta_p^2 = .18$. Autonomy-supported participants also displayed a significantly larger ERN than those in the controlling condition ($M$ = −3.88;

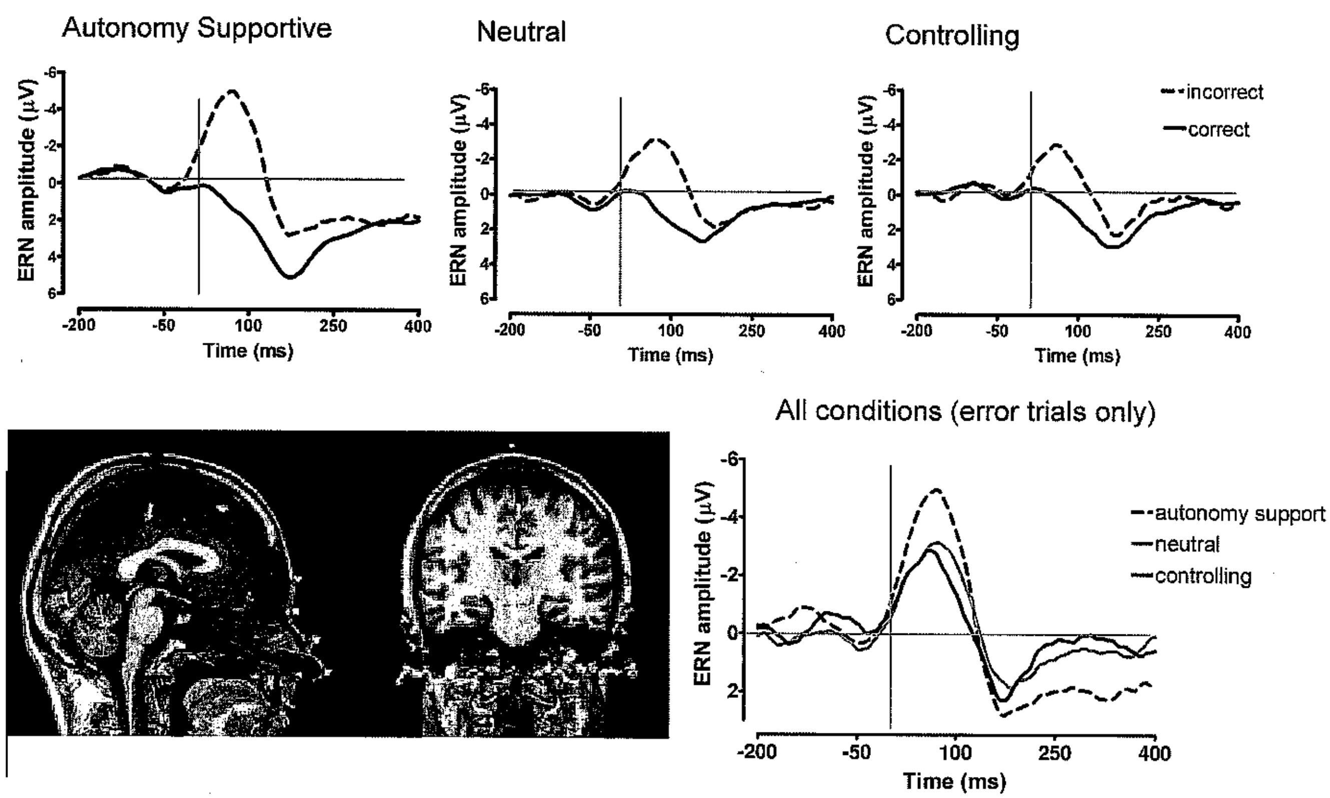


*Figure 4.* Differences in the ERN as a function of autonomy support. ERN = error-related negativity.

$SD$ = 2.24), $F(1, 34) = 11.59$, $p < .01$, $\eta_p^2 = .26$. These results indicate that all three groups displayed comparable neural responses to successful regulation; it was instead their responses to self-regulation failure that differed. There was no significant ERN difference between the neutral and controlling conditions ($F < 1$), which suggests that instilling pressure/control produces no more error monitoring than doing nothing to boost incentive. Finally, we verified that, although error rate was significantly associated with the ERN, $F(1, 51) = 6.22$, $p < .05$, $\eta_p^2 = .11$, condition remained a significant predictor of ERN amplitude even after controlling for error rate, $F(2, 51) = 4.08$, $p < .05$, $\eta_p^2 = .14$.

Dipole source localization confirmed that the ERNs were generated in an area around the ACC (preauricular-nasion coordinates, in millimeters, were $x = .15$, $y = 0.0$, $z = 50.0$). Dipole strength was 66.33 nAm, and this source accounted for 91.8% of the variance of the signal. When using only 32 electrode channels, source localization in EEG is not as precise as certain other neuroscientific methods. Nonetheless, the localization found here is consistent with previous source localization (Pizzagalli, Peccorralo, Davidson, & Cohen, 2006) and magnetoencephalographic (Miltner et al., 2003) and intracerebral findings (Brázdil, Roman, Daniel, & Rektor, 2005).

In sum, these results suggest that motivation does indeed wield an influence on the ERN, but only when that motivation is autonomous. We can conclude that the presence of incentives or motivational salience in itself does not increase performance monitoring (as suggested by previous research; e.g., Weinberg et al., in press) but that effective task engagement is enhanced when motivation is experienced as volitional and self-driven.

**Autonomy and performance: The mediating roles of perceived self-determination and error monitoring.** Finally, we tested the mediating effect of both perceived self-determination and the ERN on the link between motivational condition and self-regulation performance (please see Figure 5). We chose a different mediation strategy from Study 1 because we wanted to examine two mediators rather than one; we also wanted to assess the link between the mediators. Therefore, a test of multiple mediation was performed using the SPSS modeling macro procedure, MEDTHREE, outlined by Hayes, Preacher, and Myers (2011). This multiple mediation procedure offered the advantage of testing two mediators simultaneously rather than separately, in order to determine the overall effect of both mediators, as well as

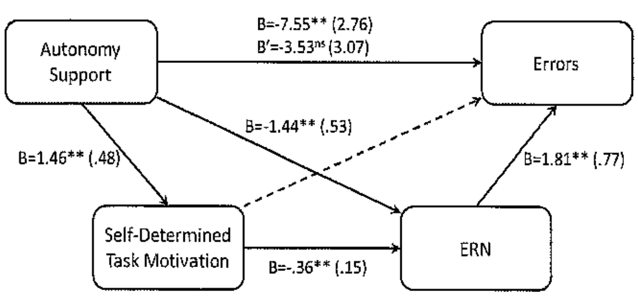


*Figure 5.* The mediating roles of self-determined task motivation and error monitoring in the link between autonomy support and performance (Study 2). Unstandardized path coefficients are presented. ERN is operationalized as the ERN–CRN difference score. ERN = error-related negativity; CRN = correct related negativity; ns = not significant. ** $p < .01$.

to obtain a clearer picture of the unique effects of each mediator. The total, direct, and indirect effects of condition on performance were estimated using a set of ordinary least squares regressions. To ascertain indirect effects, percentile-based bootstrap confidence intervals and bootstrap estimates of standard errors were generated based on 5,000 bootstrap samples.

A condition variable was calculated (autonomy-supportive = 1; neutral = 0; controlling = −1), which predicted perceived self-determination (i.e., the summation of choice, interest, and value), $t(54) = 3.04$, $p < .01$, as well as ERN amplitude (i.e., after subtracting the CRN), $t(54) = -2.52$, $p < .05$. Perceived self-determination also uniquely predicted ERN amplitude, $t(54) = -2.46$, $p < .05$, and ERN amplitude, in turn, uniquely predicted performance, $t(54) = 2.26$, $p < .05$. Using the bootstrap method, the total effect of all variables (i.e., condition, self-determination, and the ERN) on performance was significant (estimate = −4.02), with a 95% bootstrap confidence interval (CI) of −8.70 to −0.93 ($SE$ = 1.98). In addition, the unique indirect effect of the ERN on the link between condition and performance was significant, estimate = −2.61, 95% bootstrap CI = −6.10 to −.26 ($SE$ = 1.50). This suggests that the ERN mediates the link between condition and performance. Furthermore, although the unique indirect effect of self-determination on the path between condition and performance was not significant, it did exert a significant mediating effect on the link between condition and the ERN, estimate = −.95, 95% bootstrap CI = −2.62 to −0.042 ($SE$ = .68). Thus, the combined effect of both mediators on performance was reliable. These findings support our hypothesis and suggest that the manipulation of autonomy increases performance on the Stroop through heightened perceptions of autonomy and enhanced neural signals of self-regulation errors.

## General Discussion

This is the first article to illustrate a clear mechanism through which autonomous motivation increases self-regulatory performance. Using both personality and situational indicators of motivational orientation, we examined the role of autonomy in promoting performance on self-regulation tasks and, in addition, assessed the neural mechanism involved in this effect. Data from Study 1 suggest that trait-level autonomous motivational orientation is positively associated with self-regulatory performance. Study 2 lends causal support to Study 1 by establishing that the support of autonomous motivation (i.e., by enhancing choice and interest in the context of a self-regulation task) also increases self-regulatory performance. In both studies, the effect of autonomy on performance was significantly mediated by brain-based error monitoring. Moreover, in Study 2, the effect of autonomy-support on error monitoring was indirectly explained by increased perceptions of task choice, task interest, and task value, which are constituent features of autonomous motivation. Thus, when participants' autonomous task motivation was supported, ensuing feelings of autonomy and task importance were positively associated ERN magnitude, which was positively related to performance.

Complementing the finding that autonomous motivation promotes error-sensitivity at the neural level, Study 2 also demonstrated that autonomy-supported individuals displayed greater response slowing after errors, compared to neutral and controlled participants. In other words, whereas those in the controlled group showed similar reaction times on trials immediately following their correct and incorrect responses, those in the autonomous motivation group took slightly longer after errors, suggesting increased error processing and correction (although their reaction times were not slower overall).

## The Quality of Motivation Is Key in Self-Regulatory Success

With this research, we wish to emphasize the importance of motivational quality in behavior and brain processes. All of the research on motivation and the ERN, for instance, has focused on the quantity of motivation, noting that the ERN increases along with the level of motivational engagement (for a review, see Weinberg et al., 2012). While motivational magnitude is certainly important in any self-regulatory activity, we suggest that the reasons underlying behavior are equally, if not more, important. That is, in the current work, autonomous motivation was related to the ERN, whereas controlled motivation was not (Study 1). Similarly, in Study 2, both autonomy-supported and controlled participants were motivated to complete the Stroop task (more so than the neutral group), but those who were autonomously motivated performed better and showed greater sensitivity to self-regulation error, at both neural and behavioral levels. Thus, we gave participants the option either to choose the task they most wanted to complete or to complete the task that we, the experimenters, wanted them to complete. Although it may seem that giving people the chance to choose the task they want (and are presumably most interested in) should elicit an increase in motivation, our data suggest that autonomy-supported participants were not necessarily more motivated toward the Stroop than controlled participants (pleasing the experimenter is indeed strong motivation) but rather more *autonomously* motivated. Accordingly, those who chose an interesting task displayed more intrinsic motivation and self-determination than did participants who completed the task at the experimenter's request. However, both motivation conditions demonstrated more confidence and more effort in the task compared to the neutral condition. In other words, both motivation groups exhibited a drive to complete the task, but they differed in the quality of this drive. Indeed, SDT suggests that engaging in that which is concordant with one's desires and goals is a more productive form of motivation. More external forms of motivation may appear to be equally as strong, at least on the surface or in the short term (e.g., the desire for wealth or fame), but to the extent that they are not autonomous, they are less likely to produce self-regulatory benefits or positive effects on well-being (Kasser, Kanner, Cohn, & Ryan, 2007; Kasser & Ryan, 1996; Ryan & Deci, 2000).

Thus, our findings offer a novel explanation for the self-regulatory benefits of autonomy. Whereas the mechanisms via which autonomy produces its deep behavioral engagement and success have previously been underresearched, we go beyond past research in self-determination theory by uncovering a basic neural mechanism underlying the effectiveness of autonomous self-regulation. In line with past work suggesting that the ERN is a primary signal for self-regulation *failure* (e.g., Inzlicht & Gutsell, 2007), we propose that the experience of autonomy heightens responsiveness to this signal. This finding may help to account for the effectiveness of autonomous self-regulation observed across numerous behavioral domains, including food and exercise regulation, smoking cessation, medication management, and the regulation of academic and work behavior.

## Autonomy and Self-Regulation Failure: The Importance of Being Aware of Negative Affect and Threat

Despite the prominence of the cognitive interpretations of the ERN in particular and self-regulation in general, recent research suggests that the ERN is associated with affect—particularly negative affect (Inzlicht & Al-Khindi, 2012). Thus, in addition to reflecting conflict detection, the ERN (and perhaps, by extension, self-regulation) may represent an affective (Bartholow et al., 2012; Hajcak, MacDonald, & Simons, 2004) and defensive/motivational (e.g., Hajcak & Foti, 2008; Hajcak et al., 2003; Luu et al., 2000) response to that conflict (see Schmeichel & Inzlicht, in press). In other words, gaps in performance are met with negative affect and reactivity.

We suggest that, in order to better understand this recent view of the ERN, it may indeed be helpful to turn to the role played by autonomy. The link between autonomy and increased reactivity might, at first, seem counterintuitive. This is because, at a dispositional level, autonomous individuals tend to display more positive (rather than negative) affect, as well as less (rather than more) psychological defensiveness in comparison to controlled individuals. Specifically, autonomous individuals tend to perceive information, individuals, and experiences openly and accurately, without distortion (Hodgins, 2008; Hodgins & Knee, 2002), and having an autonomous motivational style is thought to predict flexibility and approach in relation to novel and challenging experiences, rather than denial or defensiveness (Lakey, Kernis, Heppner, & Lance, 2008). Nonetheless, it is important to consider the adaptive and dynamic role played by both negative affect and threat reactivity in signaling when performance goals have not been met. Indeed, these regulatory signals appear to be stronger when autonomy is high.

Thus, rather than suggesting a link with negative emotionality or trait-level defensiveness, our findings suggest that autonomously motivated behavior produces a stronger affective reaction when performance is not optimal—due to the high level of engagement and investment experienced. We therefore suggest that autonomy predicts better and more accurate *awareness and acceptance of negative affect and threat*, which results in improved spontaneous coping with such negative affect and threat, including dynamic adjustments to performance that can improve self-regulation (see Teper & Inzlicht, in press). Such adaptive strategies might include vigilance to threat and acknowledgment of negative affect. This improved self-regulation may help to explain why, in the long run, negative affect and psychological defensiveness are relatively low among autonomously motivated individuals.

Furthering the notion that autonomy may promote affective and motivational "tending" to errors, recent research suggests that autonomy, more than control, permits the acknowledgment of negative affect and personal faults (Weinstein et al., 2011), and increases openness to negative feedback (Hodgins & Liebeskind, 2003; Hodgins et al., 2010). Indeed, autonomous individuals are inclined to respond to failure in a mastery-oriented fashion by accepting responsibility and focusing on self-improvement (Koestner & Zuckerman, 1994). Conversely, controlled individuals tend to deny or rationalize failure (Hodgins, 2008; Hodgins, Yacko, & Gottlieb, 2006; Lakey et al., 2008). Moreover, a criterion of autonomy-supportive contexts is that they acknowledge that errors—and their accompanying distress—are a natural part of the self-regulation/goal-seeking process and that, as such, they ought to be embraced for the information, accuracy, and authenticity that they provide (Reeve, 2009). It is possible, then, that autonomy should lead to preparedness and to attention to errors and other signals of self-regulation failure and that the ERN may underlie such awareness and openness to challenge and threat.

In sum, there are several reasons why autonomy might be negatively related to psychological defensiveness but positively related to "defensive" reactivity to threat and error. As a further point of clarification, there is some degree of semantic confusion between the term "defensive motivation" in ERN research (e.g., Hajcak & Foti, 2008; Weinberg et al., 2012) and the term "defensiveness" in the self-determination literature. The first is represented at a neuroaffective level within milliseconds of making a response, whereas the other is an overt behavioral manifestation of threatened self-esteem. More importantly, the ERN represents defensive motivation to the extent that it signifies a reactive, brain-level "gasp" at threat or error. This startle-based view of defensive responding is akin to preparedness or responsiveness to the situation at hand, which is qualitatively different from cognitive or psychological defensiveness—a process designed to protect self-esteem by ignoring and transforming the (often harsh) reality of a given situation. Indeed, our findings indicate that the interrelation among motivational orientation, negative affect, and threat awareness is more nuanced than previously suggested and that negative affect awareness and defensive reactivity (at the neural level rather than the behavioral level) may be adaptive responses germane to autonomy. Taken with other related findings (e.g., Legault, Al-Khindi, & Inzlicht, in press; Teper & Inzlicht, in press), the current research suggests that autonomy increases awareness of negative affect and threat, which serves the purpose of monitoring for discrepancies between actual and ideal behavior, and in doing so, prompts the increases in attention and perception, as well as the readiness for action, which is required for optimal self-regulation. This self-regulatory alertness helps to explain why autonomously motivated behavior is prone to succeed in meeting its regulatory objective. The continued investigation of the role of threat awareness and the resolution of negative affect in mediating the link between autonomy and various life outcomes—such as performance, decision making, goal and life satisfaction, and well-being—may prove to be a very fruitful avenue for future research.

## Boundaries of the Current Study

By mapping the neuroaffective process through which autonomous motivation bolsters performance on self-regulation tasks, this research joins recent efforts to understand the self-determined brain (see also Lee & Reeve, 2012; Murayama et al., 2010). It is important to note, however, that our findings may be limited to explaining how autonomous motivation affects performance on tasks where errors and self-regulation failures are likely. Undoubtedly, there are other key neurological mechanisms that mediate the effects of autonomous motivation more generally—mechanisms that extend beyond error monitoring and self-regulatory performance. In particular, previous functional magnetic resonance imaging (fMRI) research has linked feelings of choice (a component of autonomy) to general increases in ACC activity (e.g., Walton, Devlin, & Rushworth, 2004). This finding coheres with our more specific event-related finding that autonomy activates the error responsiveness function of the ACC. More general brain differences in motivational orientation have also been noted. For instance, Lee and Reeve (2012) have recently suggested (again using fMRI) that feeling autonomously motivated, as opposed to feeling controlled, is related to increased activity in the anterior insular cortex—a brain region associated with feelings of agency. In addition, recent work has demonstrated that activity in the anterior striatum and prefrontal cortex is reduced when intrinsic motivation is undermined (Murayama et al., 2010). As we begin to understand the neurophysiology of human autonomy, it would be prudent for future research to consider how these broader patterns of (de)activation are related to more specific processes (as those described herein).

## Conclusion

Although previous work has indicated that autonomously motivated individuals show improved self-regulation relative to controlled individuals (e.g., Muraven, Gagné, & Rosman, 2007; Pelletier et al., 2001; Teixeira et al., 2010; Williams et al., 2009a, 2009b), we take this finding further by revealing (a) the causality of this effect and (b) its underlying neural implementation. Thus, whereas previous studies have attested that autonomy boosts self-regulatory ability, the precise cognitive and neuroaffective mechanisms remained relatively unexplored. Specifically, although past research has suggested that autonomy improves self-regulation by generating more "energy" and "vitality" available to the self (Moller et al., 2006; Muraven, 2008; Muraven et al., 2008), it is not precisely or mechanistically clear what energy and vitality mean or how they are represented. Past work on "process," in other words, has relied on metaphors and less on actual information processing mechanisms. Here, we offer something more specific by demonstrating that autonomous motivation enhances basic self-regulation processes by increasing attention and emotional reactions to performance errors. Because controlled motivation does not elicit this neuroaffective effect, we suggest that the analysis of brain differences in the *quality* rather than the *quantity* of motivation is an important consideration. Indeed, cognitive models of self-regulation might be expanded by examining how autonomy further improves the error monitoring process.

In addition, by pointing to its neural underpinnings, we offer a contribution to self-determination research by clearly linking autonomy to the well-delineated performance monitoring function of the anterior cingulate cortex: autonomy increases error-related processing and distress in the service of enhancing self-regulation. Rather than reducing mind to brain function, the naturalization of autonomy instead lends additional evidence of the real, far-reaching difference between feeling autonomous and feeling controlled. Our findings underscore the importance of noncoercion in action and suggest that self-determination has a neural basis that plays a critical role in cognitive control and optimal performance.

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DISCUSSION 2:

Prior to beginning this discussion, select a peer-reviewed, scholarly article from the Ashford University Library on a particular aspect of language acquisition studied from a psychological perspective.

- **Part 1:** As you were reading this week, what vocabulary was used that was unfamiliar to you or might be to your peers? Identify three to five words from this week's content and research each word in the context of learning and cognition. Explain, in your own words, what each word means and how it is used in the context of learning and cognition.
- **Part 2:** Based on the week's discourse and content, you will access the Ashford University Library and research one scholarly article pertaining to language acquisition published within the last ten years. Provide a summary explanation of the findings in the context of your article. What implications should scholars consider based on this information? Support your explanation utilizing your course sources and your researched article.
- **Part 3:** Consider the events from the past week of your life. How does the ability to read, write, and communicate effectively affect our behaviors, actions, and knowledge development? Describe one personal real-life example of an occurrence that indicates the possible consequences when language acquisition is not well-developed or when language development creates boundaries, such as educational or employment opportunities. As you share this information, consider and apply the professional standards found in the APA Ethical Principles of Psychologists and Code of Conduct.

Your initial post should be at least 500 words in length and should establish your understanding of the content, apply appropriate methods of ethical practices, and exhibit appropriate scaffolding of personal experience to the week's content.

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# Language acquisition socialization: Sociocognitive and complexity theory perspectives

Assia BAGHDADI, M'sila University, Algeria

Although it dates back to the early 1980s, language socialization research is still regarded as one of the relatively recent realms of scholarship in applied linguistics. It is based on the premise of bringing together an analysis of social, cultural, and cognitive dimensions of situated language learning. Employing this perspective, the current research has a three-fold purpose: (a) to maintain language acquisition aspects that are represented by social, cognitive, and social-cognitive underpinnings, (b) to shed light upon the theoretical backgrounds of both sociocognitive theory and complexity theory, which have been purposefully selected to be discussed due to their bearings on language socialization, and their sharing of the view that the cognitive and the social are intricately interwoven and mutually constitutive, and (c) to depict the commonalities and differences of the two theories in order to point out the extent of convergence and divergence that they have with language socialization as well as the extent they reach in shaping a meaningful language acquisition research agenda.

**Key words:** Complexity Theory; Sociocognitive Theory; Language Acquisition (LA); Language Socialization

## 1. Introduction

Human language is exclusively a human property. It is indeed a social behavior that coexists with any human being wherever they may be, mainly because human beings are created to be social and because they need to communicate with other society members through exchanging knowledge, beliefs, opinions, feelings, etc. In one of his famous statements about language and the social aspects of human nature, Sapir (1921) argued that language "is a great force of socialization, probably the greatest that exists" (cited in Mandelbaum, 1958, p. 15).

The term language socialization represents a broad framework having as a primary goal the understanding of the development of linguistic, cultural, and communicative competence through children's verbal interaction with more proficient individuals (Duff & Talmy, 2011). It is also defined by Duff and

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Kobayashi (2010) as a process by which newcomers in a community or culture acquire communicative competence, membership, and legitimacy in that community through social interaction and (often) overt assistance, and by contributing in the group activities.

As far as a novice's membership in one particular speech community is concerned, Moore (2008) explained this issue by claiming that a novice is socialized through the use of language, and is socialized to use it through engaging in communicative encounters and in routine interactions with more knowledgeable members in order to become an active and a competent member in that community. In this sense, language socialization is not restricted to only language use and developmental processes, but it also covers the issue of the effect of those processes upon learners being accepted in the target community and their own statuses in it (Ochs & Schieffelin, 1986). In other words; the intended purpose of language socialization researchers exceeds the acquisition of linguistic conventions and pragmatics to reach the adoption of identities, stances, ideologies, and other behaviors that enable a novice to behave and be treated appropriately in the new community (Ochs & Schieffelin, 1986).

The genesis of language socialization as a paradigm was in the early 1980s by Elinor Ochs and Bambi Schieffelin, the linguistic anthropologists who conducted extensive fieldwork in non-Western societies. Between 1975 and 1977, Schieffelin conducted a longitudinal study of childern's language acquisition among the Kaluli people of Papua New Guinea; between 1978 and 1979, Ochs conducted a longitudinal study of Samoan children's language acquisition (Ochs & Schieffelin, 1984). Both researchers tended to bridge the gap between two totally separate and distinctive fields of inquiry: (1) developmental psycholinguistic research on first language acquisition, and (2) anthropological research on child socialization.

Language acquisition research focused on the individual either as acquirer or provider of language. In contrast, anthropological research depicted different communities putting the sociocultural context at the center of analysis (Moore, 2008). Schieffelin and Ochs (1986) based themselves on the premise that, for a better understanding of the two fields, they should be viewed and studied as two interacting and interdependent disciplines of scholarship whereas Moore explained, from Ochs and Schieffelin's vision, that an interaction between a child and a caregiver should be studied as a cultural phenomenon embedded in the wider systems of cultural meaning and social order of the society in which the child is being socialized (Moore, 2008).

From its beginning language socialization research was concerned with theoretical and applied issues and it evolved to be the concern of many researchers who, according to their own visions and tendencies, expanded its scope to second language acquisition and contributed to its emergence in the early 1980s as a new area of scholarship in applied linguistics (Duff & Talmy, 2011). They even helped language socialization paradigm to integrate theoretical perspectives and methods from a variety of disciplines such as (1) linguistic anthropology, (e.g., Duranti, Ochs, & Schieffelin, in press; Hymes, 1972; Schieffelin & Ochs, 1986a), (2) sociology (e.g., Bernstein, 1972; Bourdieu, 1977; Giddens, 1979, 1984), (3) cultural psychology (e.g., Lave & Wenger, 1991; Rogoff, 1995, 2003), (4) systemic functional linguistics (e.g., Halliday, 1980, 2003), (5) semiotics (e.g., Hanks, 1992); (6) cultural-historical psychology/sociocultural theory and activity theory (e.g., Engestrom, 1999; Leontiev, 1981; Vygotsky, 1978), and more recently, (6) discursive psychology including positioning theory (e.g., Bamberg, 2000; Korobov & Bamberg, 2004).

Within language socialization, we distinguish two types: (a) first language (L1) socialization, and (b) second language (L2) socialization. In contrast to first language (L1) socialization, second language (L2) socialization deals with issues related to children or adults with already constructed repertoires including linguistic, discursive and cultural practices as they interact with veterans from a new community. Moreover, it should be noted that second language (L2) socialization is bidirectional where the more proficient interlocutors are also socialized by novices into their identities, and they may learn from the newcomers their specific communicative needs and may also learn from these learners' perspectives and prior experiences (Duff & Talmy, 2011).

In the socialization paradigm the concept of communicative competence is central. This concept was firstly proposed by Hymes (1972), who defined it as the learner's ability to appropriately use grammatically correct language in real context. Communication in Hymes' viewpoint (1972, cited in Salmani Nodoushan, 2013) entails two steps where the speaker is supposed (1) to construct an evaluative vision about the speech context, and then (2) to decide upon the appropriate communicative options that enable him to encode what he intends to convey as a message (cf., Allen & Salmani Nodoushan, 2015; Capone & Salmani Nodoushan, 2014; Salmani Nodoushan, 1995; 2006a,b; 2007a,b; 2008a,b; 2012; 2014; 2015; 2016a,b,c; 2017; 2016; Salmani Nodoushan & Allami, 2011). Researchers interested in language socialization focus on the development of this competence as a process in which a novice is socialized into the linguistic and the socio cultural activities of the target speech community (Moore, 2008 ).

Also fundamental to this paradigm is the notion of 'practice' which is represented in language socialization by speaking and listening. This practice enables the novice to participate in community activities with increasing competence and commitment into community practices (Bourdieu, 1977).

In language socialization, research studies are typically ethnographic. Generally speaking, ethnographic research tends to understand the cultural patterns and values of groups in their local contexts (Duff & Talmy, 2011). As this type of research is based on persistent engagement in and on extensive observation of contexts, it helps researchers to have access to a broad description of the cultures, communities and other dynamic social settings (Bronson & Watson-Gegeo, 2008; Duff, 1995; Schieffelin & Ochs, 1996).

Garrett (2008) identified the core methodological features of language socialization research by summing them up under the following:

1) Longitudinal research design: As language socialization studies develop, it is necessary to cover the different transformations that occur over a period of time and engender development.
2) Field-based collection and analysis of a substantial corpus of audio or video recorded naturalistic discourse: This enables the researcher to repeatedly examine communicative behaviors and to identify patterns in novice interactions in close detail.
3) Holistic and theoretically-informed ethnographic perspective: From this perspective, researchers refer to prior research on the target social community from a variety of disciplines to give a locus to their study in the broader social, cultural, and historical context.

As such, a language socialization researcher is not restricted to study the detailed ethnographic accounts of the development of individuals in specific social communities, but he/she goes further to comprehend how these developmental processes relate to social, cultural, and historical processes (Moore, 2008).

As language acquisition socialization research is mostly concerned with bringing together an analysis of social, cultural, and cognitive dimensions of situated language learning, it seems highly compatible with two newly emerging theories: (1) the Sociocognitive Theory (cf., Atkinson, 2002) and the (2) the Complexity Theory (cf., Larsen-Freeman, 1997); both of these theories consider the cognitive and the social to be intricately interwoven and mutually constitutive. Along the same lines, the present paper attempts firstly to elucidate language acquisition aspects, and secondly to contribute to a greater understanding of both theories through shedding light on their insights and conducting a comparative analysis on them to find answers to the following questions:

1) What are the commonalities and differences of Sociocognitive and Complexity theories?

2) What do they have in common with language socialization approach, and how do they differ from it?
3) To what extent do they contribute to shape a language acquisition research agenda?

## 2. Language acquisition: Cognitive, social, and social-cognitive aspects

From its early days, second language acquisition focused on the cognitive dimensions of language acquisition. After that, the scope of this focus was broadened to include socially-oriented dimension of the acquisition process. Thus, second language acquisition researchers were divided into two camps: (a) Those who called for the cognitive aspect maintaining that SLA is basically cognitive, and (b) those who rejected that stance and emphasized the primacy of the social account of SLA. Recently, however, a new trend emerged to accommodate both the cognitive and the social aspects.

The first trend represented by cognitivists was influential over the past thirty years or so (cf., Doughty & Williams, 1998; Gass, 1997). Cognitive approaches have tended to focus on the patterns that can be observed in the output produced by the learner without referring to the learner's nature or the context in which he is learning (Doughty & Long, 2003). Hence, experimental approaches prioritized the treatment of decontextualized language samples where the crucial focus of interest has been on either the cognitive representation or processing of linguistic information (Robinson & Ellis, 2008); nevertheless, the cognitive accounts appear to have a social orientation. From this perspective, the cognitivists argue that language acquisition has its genesis in processes of turn-taking in language use, and that interaction is understood as a mechanism for generating input thereby activating the various cognitive mechanisms involved in information processing (Batstone, 2010). Moreover, the concept of negotiation either of meaning (Long, 1996) or of form (Lyster & Ranta, 1997) is also central to cognitive accounts. Due to these accounts and arguments, cognitive approaches have been criticized for decontextualizing language—which cannot be separated from the context in which it is produced (Block, 2003).

The second trend is represented by theorists who are thought to be socially oriented researchers (e.g., Wagner, 2004), and who argue that although the mind is undoubtedly involved in the process of language learning, factors such as (a) the contextualized nature of language, (b) the role of social factors, and (c) the importance of social participation should not be marginalized. Wagner, for instance, argued that:

> The theory of learning as participation simply avoids statements about the participants' inner states. The participants are socialized into

> practices, but the description has no means to show what kind of inner states are related to the process of becoming a member in a social group.
>
> (Wagner, 2004, p. 614)

Based on Wagner's (2004) stance, the mental aspect of language was not denied, but it was rather left to other methodologies. The focus should be on participation itself rather than on the learning that might occur within the interactive context. Dornyei and Ushioda (2009) added that, from a social perspective, the learner's identity has its roots in the social relations he experienced within one specific community.

However, from the perspective of the sociocultural theory, the social is seen as interacting with dimensions of mental processes where the innate is transformed through socially constructed processes. That is, biological constructs such as attention and memory are seen to be crucially impacted through encounters with other activities and concepts (cf., Lantolf, 2006). This vision led to the emergence of a third trend.

The third trend based itself on the view that neither language use nor language learning can be adequately defined or understood without recognizing that they have both a social and a cognitive dimension which interact (Batstone, 2010). Watson-Gegeo and Nielsen (2003, p. 156) argue that:

> The cognitive/social dichotomy widely taken for granted in SLA theory obscures the relationship between the knowledge about language that learners construct and the social, cultural, and political contexts in which acquisition takes place. Cognition originates in social interaction. Constructing new knowledge is therefore both a cognitive and a social process. SLA theory's [*sic*] need for just this sort of integrative perspective is one of the arguments for taking a language socialization approach in L2 research.

Indeed, the social and the cognitive were the concern of many researchers. However, they might have been distinguished according to their relative view on the relative primacy of the social versus the cognitive. From this perspective, Duff and Kobayashi (2010) claim that none is superior and suggest the language socialization approach as a good example combining the two tendencies and offering an interesting way of contextualizing and theorizing activity-based language learning, tasks, participants, and communities or cultures. The following section explicates successively the rationale of the sociocognitive and the complexity theories as two good examples supporting the duality of second language acquisition that is represented by the social and the cognitive dimensions. Also it elicits the methodological principles on which they are based; it highlights the commonalities and the differences that exist among them, and points out the points of convergence and divergence that they have with language socialization.

## 3. The Sociocognitive theory

Sociocognition is a concept introduced by Atkinson (2002) to accentuate the interplay between the physical and the social worlds to which individuals are attuned, and even the patterns they produce and use internally. Batstone (2010, p. 5) argues that "Sociocognition is based on the view that neither language use nor language learning can be adequately defined or understood without recognizing that they have both a social and a cognitive dimension which interact."

Sociocognition as a theory is viewed by Bandura (1985) as an explanation of how humans think, and why they are motivated to follow particular actions in society. As far as learning is concerned, it is defined from a sociocognitive perspective as an internal mental process that may or may not be reflected in immediate behavioral change (Bandura, 1986). Learners, as practitioners, are viewed as dialectically connected to the social contexts in a synergetic relation (Meskill & Rangelova, 2000). To sustain the rationale of the sociocognitive paradigm, Atkinson (2002, p. 537) calls for a greater integration of the social and cognitive in L2 research, with a greater focus on the process of the learner's inclusion and participation within situated linguistic activities:

> a sociocognitive approach to SLA would take the social dimension of language and its acquisition seriously . . . . Second, language and its acquisition would be fully integrated into other activities, people, and things in a sociocognitive approach to SLA. They would be seen as integral parts of larger sociocognitive wholes, or, in Gee's (1992) term, Discourses . . . . Third, language and its acquisition, from a sociocognitive perspective, would be seen in terms of 'action' and 'participation'—as providing an extremely powerful semiotic means of performing and participating in activity-in-the-world (Rogoff, 1990, 1998; Lave and Wenger, 1991). Finally, a sociocognitive perspective should not, strictly speaking, exclude. As an approach to language, it is fundamentally cognitive and fundamentally social . . . it argues for the profound interdependency and integration of both.

Sociocognitively speaking, second language learners can learn a language in a better way if their cognitive capabilities are employed along with their social interactions. This view was, in fact, underpinned by the sociocultural theory presented by Vygotsky (1978) who stated that human beings' cognition is defined in relation to the social interaction of the individual within his own culture where his thoughts, actions, and experiences are all socially and culturally mediated. Moreover, he claimed that individuals will be able to learn and develop when they are capable to differentiate individual consciousness from others and from the environment (Vygotsky, 1978). With the aim of making his theory more explicit, Atkinson (2010b) presents three principles on which sociocognitive approach to second language acquisition is based: (1) The Inseparability principle, (2) the Learning-Is-Adaptive principle, and (3) the Alignment principle.

- The Inseparability principle: According to Batstone (2010; cited in Atkinson (2010b, p. 27), the inseparability principle is the one in which: ". . . the social and the cognitive are indivisible and can only be properly understood by keeping their essential unity intact." More explicitly, Atkinson (2010b, p. 27) explicates that "Mind, body, and ecosocial world are inseparable contributors to SLA processes, so to understand such processes these elements must be considered together."
- The Learning-is-adaptive principle: In this principle, Atkinson (2010b, p. 27) claims that "learning is largely a process of better adapting to our ecosocial environment." Although he admits that the mainstream learning theories, including SLA studies, assume that learning occurs for its own sake being conceptualized as progressive separation of knowledge from the environment, Atkinson states the opposite arguing that since cognition is ecosocial entailing the adaptive action; as the embodied cognition enables humans to adapt to their environments, and as learning is cognitive process, thus learning is adaptive (Atkinson, 2010b).
- The Alignment Principle: It is the third principle, and turns around the construction of the social meaning. It is conceptualized by Atkinson (2010b) as a major mechanism of SLA, where the participants, due to the participation in the ongoing construction of meaning in sociocognitive space, learn how to mean in an L2. He extends this conceptualization by defining alignment as ". . . the means by which social actors participate in the ongoing construction of social meaning and action in public/sociocognitive space. In mutually attending, negotiating, sharing information and emotions, solving interactional/ communicative problems, building participation frameworks, interacting with their extended cognitive surroundings, etc., social actors dynamically adapt to their environments, creating shared meaning in mind-body-world" (Atkinson, 2010b, p. 29).

In the sociocognitive paradigm, according to Atkinson (2011), SLA research study is just beginning, and any account of its research methods must be emergent and prospective. He maintained an exploratory set of methodological principles on which sociocognitively oriented SLA research might be based claiming that his ultimate purpose is merely to provide guidance in designing studies that can deepen our understanding of how mind, body, and the world work together in SLA.

One of the core claims of sociocognition is the extension of mind into the world through social tools and systems, where Atkinson (2010a, 2010b) justifies the interest of socio-cognitive methodologies in looking for cognition in worldly artifacts and practices and mainly in how they integrate mind, body, and the world. Starting from the premise that much, if not all, L2 learning takes place via interaction, Atkinson believes that sociocognitive research methodologies would therefore examine language learning in interaction, and put the emphasis on studying real-world L2 use.

Although SLA is a process, mainstream SLA research focused typically on the linguistic products of SLA based upon knowledge of language as object (Doughty, 2003). From a sociocognitive viewpoint, Atkinson (2010a,b) argues that SLA is a continuous, complex, nonlinear process that takes place at the level of interaction. Atkinson favors the variety of the individuals' experiences since it enriches the researcher's understanding of human beings; without denying the existence of the common developmental trajectories, he appeals to the rejection of uniform, mechanical, teleological development as a necessary guiding assumption of SLA research.

## 4. The Complexity theory

The Complexity theory is defined by Larsen-Freeman (1997) as a theory that seeks to explain complex, dynamic, open, adaptive, self-organizing, nonlinear systems. It focuses on the close interplay between the emergence of structure on the one hand, and process or change on the other. It has its roots in the physical sciences, but it has been applied to many social sciences such as economics, epidemiology, and organizational development. This is because complexity theory affords a transdisciplinary perspective (Halliday, 1990). Rather than seeing the world through a deterministic, reductionist, Newtonian lens, complexity theorists adopt a more holistic perspective (Larsen-Freeman, 1997).

Larsen-Freeman (2011, p. 49) perceived deep parallelism with language acquisition which she explains in her words as:

> . . . in contrast to my own (generative) training in linguistics, I came to understand language as a complex adaptive system, which emerges

bottom-up from interactions of multiple agents in speech communities rather than a static system composed of top-down grammatical rules or principles. The system is adaptive because it changes to fit new circumstances, which are also themselves continually changing.

In Complexity theory, Larsen-Freeman (2002, 2007) looked for a way to integrate the social and the cognitive rather than segregating them. The issue of interconnectedness is crucial to complex systems, and of great importance, when dealing with language which is viewed by Larsen-Freeman (2008) as arguably complex systems. Hence, it provides a ground to unite different language phenomena such as language development, its evolution, its learning, its teaching, and its use. From this perspective, Larsen-Freeman claims that "Complexity theory characterizes this relationship by suggesting that cognitive and social forces operate simultaneously, albeit on different levels and at different timescales" (2010, p. 51) where the linguistic system can be ". . . defined as a dynamic adaptedness to a specific context" (Tucker & Hirsch-Pasek, 1993, p. 362). Language learners modify and change their language resources, as they try to adapt their language resources to new contexts leading to the emergence of a reciprocal causality between the language system and its use to become mutually constitutive. Additionally, a common dynamic process operating at different time frames is manifested by language use and language learning. In other words language learning occurs when people use it (Larsen-Freeman, 2010).

When it comes to second language learning, the contrast between instructed and uninstructed context is invoked by Larsen-Freeman (2003), who believes that few generalizations may be held across different learning contexts. From a Complexity theory point of view, language learners must be provided with abundant opportunities of language practice. Moreover, Larsen-Freeman (2010) proposes that we should 'teach grammaring' rather than 'grammar'. Within the 'grammaring' approach, the dynamism of language learning and use should be extended to the construction of meaning through adopting a psychologically authentic approach. Moreover, she introduced a set of theoretical principles on which her theory is based. The three main principles are explained below.

- The first principle considers language as a dynamic set of patterns emerging from use, where those patterns transform into stable entities within a complex system. In this sense, Beckner et al., (2009, p. 11) argues that "Sequences of elements come to be automatized as neuromotor routines," with grammar considered as a by-product of communication not as the source of understanding and communication (Hopper, 1998). They are patterns which Tomasello (2003) calls 'constructions'—i.e., form–meaning–use composites, having graded borders not discrete ones, ranging from single morphemes to idioms to partially filled lexical patterns to complex clauses (Larsen-Freeman, 2011).

- The second principle focuses on the adaptation of language-using patterns to their context of use. As Larsen-Freeman (2011, p. 53) stated, "As with other complex systems, language-using patterns are heterochronous: Language events on some local timescale may simultaneously be part of language change on longer timescales," and "the system changes every time a form is used."
- The third principle deals with language development which proceeds through soft-assembly and co-adaptation in social context. From a complexity theory perspective, such a context contributes significantly to language development by affording possibilities for co-adaptation between interlocutors (Larsen-Freeman, 2010). According to Larsen-Freeman, co-adaptation is an iterative process; indeed, language development itself can be described as an iterative process with learners visiting the same or similar territory repeatedly. With each visit, learners soft-assemble their language resources. The term soft-assembly was coined by Thelen and Smith (1994), who thought that an assembly is said to be 'soft' because the elements being assembled, and even the ways they are assembled, can change at any point during the task or from one task to another.

In complexity theory, research was a challenge that compelled researchers to rethink traditional research designs because, according to Larsen-Freeman and Cameron (2008b), it has to deal with dynamic, nonlinear, open complex systems that are organized and interacted across different levels and timescales. The challenge was represented firstly by the problematic nature of limiting the focal point of interest and of singling it out from the whole mainly that everything is interconnected, and secondly by specifying the boundaries of a complex system that is open to the environment (Cilliers, 2001). Bateson (1972, p. 465) explains that the "way to delineate the system is to draw the limiting line in such a way that you do not cut any of these pathways in ways which leave things inexplicable."

To solve these problems, three methods were proposed by Van Gelder and Port (1995) for studying dynamic systems: (a) quantitative model, (b) qualitative model, and (c) dynamical description. In the quantitative model, Larsen-Freeman (2011) claims that complexity researchers prefer adopting computer simulations; although they are approximations, they are easy to manipulate and can help to provide more explorations on different factors and variations influencing the phenomenon at hand. This choice was taken deliberately due to intrinsic difficulty they find when dealing with human beings using mathematical models.

The Qualitative model, using computer simulation, was employed in applied linguistics from a complexity theory perspective (Meara, 2006). This model, according to Larsen-Freeman (2011), proved its usefulness because computers are programmed on the basis of explicit assumptions where the researcher finds himself forced to make explicit the assumptions he puts about the complex system he is investigating. Additionally, it was used successfully in social sciences to cope with large-scale regularities from individual agents interacting locally.

The third model is concerned with dynamical description of complex systems. From this perspective, Van Gelder and Port (1995, p. 17) state that this model "provides a general conceptual apparatus for understanding . . . systems including, in particular, nonlinear systems and change over time." The ethnographic method is also employed since it provides dynamic descriptions which, in Atkinson's view, "attempts to honor the profound wholeness and situatedness of social scenes and individuals in the-world" (2002, p. 539).

Larsen-freeman (2011) believes that the central work of complexity theory is to describe complex systems retrospectively. That is, once change has happened, unlike the usual scientific method which calls for making predictions and then testing them, it may lead to problems from a complexity theory perspective. However, she explicitly admits the inability of the theory to offer useful tools that help to provide accurate details about individual changes and dynamic cases (Larsen-Freeman, 2011, p. 63):

> Complexity theory increases our understanding of complex systems, but it does not present us with tools to predict or control behavior accurately. We may thus learn a lot about the dynamics involved in the functioning of such systems, but we will not be able to use these general principles to make accurate predictions in individual cases. Complexity theory underscores the importance of contingent factors, of considering the specific conditions in a specific context at a specific time. No general model can capture such singularities.

The rationales of the two theories as well as their theoretical underpinnings, and also their methodological principles, have been presented up to here, and now a comparative overview will be presented in the following section.

## 5. Sociocognitive theory vis-à-vis complexity theory

A thorough understanding of the two theories as newly emerging ones shows that Larsen-Freeman's complexity theory approach to SLA has much in common with Atkinson's sociocognitive approach. Indeed, it has partly inspired it (Atkinson, 2002). Larsen- Freeman (2008) adopted the sociocognitive concept, where she declared in different settings her inclination towards the integration of sociocognitive approach implicitly and explicitly.

Complexity theory shares features with the sociocognitive theory, such as the unified view of the social, the cognitive, the groundedness in data, the attention to detail in conversation analysis, and the adaptation principle. Moreover, complexity theory shares with the sociocognitive theory the view that cognition (or higher mental functions) emerges from ongoing social interaction, and that mind affects the social contexts it operates in. That is, both support the surrounding accounts of learning that place its locus exclusively neither in the brain/body nor in social interaction, but in their intersection (Larsen-Freeman, 2011)

Speaking about the differences existing between the two theories, we may mention two major ones: the divergent origins of complexity theory, and the sociocognitive approach. The former originated in statistical physics and systems theory—i.e., mathematical approaches to describing natural processes. The latter would be wary of mathematically inspired explanations of human behavior, given the origins of cognitivism in a mathematized and mechanistic worldview (Atkinson, 2011). The second difference has to do with research methods adopted by each theory. As mentioned by Larsen-Freeman (2011), complexity theory relies on a retrospective approach in studying natural processes, including SLA. However, in the sociocognitive approach, processes are studied 'in-process'. Nevertheless, there were attempts to study learning processes as they unfold, rather than after they have happened.

In the realm of SLA research, researchers impacted by the Chomskyan approach to language draw on other methods of investigation from other disciplines in order to objectively understand the phenomenon of language acquisition that is viewed as something residing within the individual relying on psychological factors (cf., Navidinia, 2010). Complexity theory and sociocognitive theory represent two typical examples which still reflect a more philosophical framework than a sustained and systematic empirical approach to SLA. Because both theories are still new in their empirical investigations of SLA, it remains unclear what their typical methodological approach or linguistic focus will be (Duff & Talmy, 2011).

## 6. Sociocognitive and complexity theories and language socialization

In fact, from what went before, it can be argued that complexity and sociocognitive theories have much in common with language socialization. They all share a social, interactional, and cognitive orientation to language learning which is regarded as a set of processes that reflect the development of the human mind (Duff, 2007). They also appreciate the necessity of culturally organized and interactional activities for meaning-making and learning, insisting on the key role played by more proficient interlocutors, peers, caregivers, or teachers in helping novices or newcomers to actualize their potentials by means of assistance and scaffolding (Larsen-Freeman, 2011).

However, language socialization differs from these two theories in important ways. Unlike language socialization which puts a greater emphasis on the *social* and the *cultural* in psychological experience, including language learning, sociocognitive and complexity theories prioritize linguistic forms that are acquired by learners in the context of social interaction (Duff & Talmy, 2011). Additionally, socialization research, when dealing with L2, deals simultaneously with the socialization of L1, L2, and multilingual learners in situations of language contact (Moore, 2008). Furthermore, language socialization research and theory has long been concerned with both the language and learning practices of novice members of society and those of experts, as well as the development they reach along their lifespan through encountering new forms of language use. However, with the two theories, it is only recently that SLA has become more interested in the relationship between learning and oral language development (Tarone & Bigelow, 2009).

## 7. Conclusion

Through this paper, it was clearly stated that, as a theoretical and methodological approach, language socialization has taken roots over the past two decades, builds on different disciplines to show how learning and social experience go hand in hand and are part of a process of internalization, performance, and personal transformation through mutual engagements with others as learners become better equipped to function in society as communicatively competent members (Duff, 2007a). This vision was depicted through analyzing two distinctive and newly emerging theories: the sociocognitive theory and the complexity theory, both of which emerged to bring together an analysis of social, cultural, and cognitive dimensions of situated language learning, and both of which share many viewpoints with language socialization and differ from it in several ways.

Through this review, we have sketched the sociocognitive approach to SLA which attempts to study human mind as it extends into the body and ecosocial world. Nevertheless, in Atkinson's view (2011, p. 38), "Most uses of the term 'sociocognitive' stop well short of this point, still relying in one way or other on the old inadequate cognitive/social division." The Complexity theory was also highlighted where its stance in theorizing language behavior in SLA in particular is summarized by Kramsch (2009, p. 247), who argues:

> Complexity theory, which originated in the physical sciences, has been used as a productive metaphor in SLA to stress the relativity of self and other, the need to consider events on more than one timescale and to take into account the fractal nature and unfinalizability of events.

Finally, irrespective of the commonalities and differences among the various alternative approaches to language acquisition (LA), they still continue to evolve and lead language acquisition (LA), as a scholarship discipline, to be enriched by more in-depth and largely contextualized research studies.

## The Author

Assia Baghdadi (Email: assiabaghdadi1@live.fr) is a lecturer in cognitive psychology and pragmatics at the University of M'sila in Algeria. She is also a researcher interested in applied linguistics, psycho-pedagogy, and the teaching and learning of foreign languages. She has different publications about the methodology of teaching and learning of foreign languages and language learner cognition.

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