Chapter

When Aggression Is Out of Control: From One-Person to Two-Person Neuropsychology

J. Gagnon, J.E. Quansah and W.S. Kim

Abstract

From a neuropsychological perspective, impulsive aggression and its treatment are usually conceptualized in most research as a closed executive functioning system, as though the behavior was the product of the person's cerebral functioning only. However, recent studies in social cognitive neuroscience have emphasized the influence of social factors on cognitive processes and cerebral functioning for the development and maintenance of impulsive aggression. This chapter will review studies that highlight the relevance of initiating a shift of paradigm from a one-person-cerebral functioning model to a social interactive-cerebral functioning model of impulsive aggression. First, the influences of an aversive environment on a child's cognitive processes and executive functioning will be discussed with the aim of explaining the development of impulsive aggressive behaviors in early childhood. Second, we will review studies that have shown how the link between social information processes and executive/inhibitory functioning serve to maintain behaviors. Finally, strengths and weaknesses of existing inhibitory control strategies will be discussed with the intention of proposing some novel ideas that incorporate a two-person neuropsychological approach.

Keywords: impulsive aggression, executive functions, inhibitory processes, social information processing, child development, treatment, inhibitory control training, implementation intentions

1. Introduction

When facing a dangerous or threatening situation, aggression is a behavioral response that is often appropriate and necessary. An individual who is unable to perceive the hostile intentions of others is also unable to protect him- or herself or their personal needs. Aggression can also be characterized as a vital energy that allows an individual to mobilize the physical and psychological resources necessary to compete with others in a healthy way. Finally, aggression is present in many positive forms of emotional expression; it gives rise to creativity and the establishment of new relationships. It is when aggression is out of control that it becomes unbeneficial, problematic, and potentially harmful. Lack of control over the intensity, form, and timing of aggressive behavior is thus an issue of interest to clinicians who would like to help people with uncontrolled aggression.

The defining characteristic of impulsive aggression is uncontrolled and impulsive behavioral manifestations of anger in response to a provocation [1]. Aggressive behaviors have a negative impact on social, legal, and health-care systems, and are significant predictors of long-term social dysfunction [2]. Consequently, understanding and preventing aggressive behavior is a worldwide major public health concern [3]. Impulsive aggression is also associated with violent forms of aggression, which often occur in the context of interpersonal relationships [4]. When considering the importance of the social dimension in models of impulsive aggression, this observation is not surprising. While many of these models have come from social psychology, contributions from neuroscience have increasingly allowed for the inclusion of the social component, with the aim to produce more integrative models. This has opened up the field and made it possible to explore how cerebral connectivity may vary according to distinct social inputs and the reaction to those inputs.

The purpose of this chapter is to reflect on new avenues of intervention that are based on *both* social psychology and neuroscience models. We believe that inhibitory control training (ICT) represents a unique opportunity by which this may happen. Indeed, ICT addresses impulse control disorders and, in this sense, may be a relevant intervention strategy for impulsive aggression. However, to adapt it to the peculiarities of impulsive aggression, one must proceed with careful deliberation. It is here that our analogy with two-person psychology comes into play. The term "two-person psychology" comes from a clinical psychology approach, which means that the emotions and subjective reactions of the client and the therapist during a psychotherapy session are not only determined by the client's dynamics but also by the mental life of the therapist [5]. The personal reactions of the therapist are part of the session; they not only influence the interactional processes in the dyad [6] but they also contribute to the transformation and therapeutic change, as experienced by the client [7]. Inspired by this clinical approach, we will propose that ICT may be integrated into impulsive aggression treatment programs if it is extended into the social realm, and more particularly to social cognition. To do this, we believe that an intervention strategy called *implementation intentions* can bridge the gap between ICT and the field of social cognition.

Before discussing these methods of intervention, we will review evidence of the social determinants of aggressive impulsive behavior. We will begin by looking at the influence of aversive social environments on the development of social cognition and inhibition in children. We will then discuss how social and neurobiological models can shed light on the factors that maintain aggression in adults.

2. Development of hostile cognitive structures in early childhood

Aversive early childhood experiences and environments, which include physical or psychological abuse, inconsistent or severe discipline, parental neglect, social rejection, exposure to aggressive peers or violence, among many others, have all been identified in the literature as constituting important risk factors of disruptive and aggressive behavioral problems later in life [8–10]. Here, we will present some of the evidence-based theories that explain how early life social adversity affects the development of a child's mental processes and is believed to increase the likelihood of future aggressive behavior.

2.1 Social cognition and the influence of aversive childhood environments

In cognitive psychology, social information processing (SIP) models postulate that in a person's memory, there exists a collection of memories of past experiences.

In this pool of memories, accumulated information is thought to bind together, forming stable structures of concepts and sets of principles. These organized sets are often called schemas, and they guide a person's behavior in social situations [11, 12]. An individual who was physically abused as a child may have an accumulation of aggressive social experiences stored in memory. Over time, aggressive thought and belief patterns may develop and lead to aggressive behavior.

A *schema* (also referred to as a "script"; [13]) can be described as a network of associative concepts that are stored in memory and function to organize past experiences—to make sense of the world and absorb new knowledge efficiently [14, 15].

Imagine a person is approaching you with a big smile and a hand raised up high. If you have had past experiences of giving someone a "high five," then it is likely that the smile and the raised hand (which are "encoded" in the current situation) will be interpreted as a friendly gesture. Given past experiences, it is unlikely that you will assume they have harmful intentions. Now, let us imagine that this person is someone with whom you would like to become friends. You remember that past occurrences of returning a "high five" have helped you attain a similar goal with other people. This cognitive process leads you to decide to gently tap the person's hand "up high." From a cognitive psychology perspective, the schema in this situation contains concepts such as a "smile," a "raised hand," a "high five," a "non-harmful intention," a "friendship," and a "positive experience," and these concepts are associated together with past experiences.

Now, this time try to imagine the same situation, but as it might happen with a child who has experienced physical abuse. The schema evoked here would likely be quite different. It may contain concepts such as a "smile," a "raised hand," a "slap on the face," a "harmful intention," a "threat," or a "negative experience." While the initial situation—a person approaches with a big smile and a raised hand—is the same in both examples, it is unlikely that the child who was abused would react, or behave, in the same manner as in the situation above.

2.2 Schemas biased toward hostility

While a schema can be a cognitive structure that helps process social information efficiently, it can also omit details and induce errors. Because schemas are formed by past experiences, recurrent negative events and early aversive experiences may influence certain schemas in such a way that they become biased. As a result, a person may be misled by their interpretations and react with aggressive behavior. For example, what if the child mentioned above had decided to hit the person in order to run away. Had the person who approached the child been intending to cause harm, then the child's aggressive behavior would have potentially helped them avoid a slap on the face. However, if the child repeatedly uses this schema and reacts aggressively in every social situation, then this will result in a chronic accessibility of hostile schemas [16, 17] and a frequent hostile interpretation of the behavior of others (hostile attribution bias; [11, 18, 19]).

2.3 Schema formation through observation

Research evidence on early exposure to media violence (as depicted on television [TV], movies, video games, cell phones, online/computer sources, etc.) has shown that hostile schemas formed in childhood do not *only* develop from direct exposure to aggression (e.g., actual physical or verbal abuse). They can also result from *indirect* exposure—through the observation of aggressive acts as depicted by individuals in violent media [12, 20, 21]. Because a schema acts as an associative network of concepts, a stimulus may activate a concept, which then activates other

associated concepts that are part of the same network. In this way, a schema can be implicitly activated (or "primed") by a stimulus and trigger a chain-like reaction between associated concepts within a particular network [22, 23]. It is important to note, however, that there is a difference between schemas that occur during adulthood, and those that develop earlier in life. Adults often have schemas that were acquired through accumulated experiences, and this serves to strengthen the links between associated concepts, making them highly resistant to change. By contrast, a child's schemas are much more flexible and impressionable, making it much easier to encode new information. While this is a key component that contributes to social learning, it can also make children more vulnerable when exposed to aggressive stimuli [24]. A child who observes a violent scene on TV will encode aggressive cues without difficulty, and often without filter. The more the child is exposed to such media violence, the more the links between concepts of aggression will be reinforced, and these aggression-related concepts will create additional links with other concepts from memory. With frequent repetition of this process, activated aggressive schemas will expand, become chronically accessible, and resistant to change. Indeed, longitudinal studies have shown that children's early hostile schemas contribute to the stability and maintenance of later aggressive behaviors [25].

2.4 Normative beliefs

The term *normative beliefs* refers to an individual's personal standard about the appropriateness of particular social behaviors [26]. In other words, they serve to determine which behavior is appropriate versus inappropriate in a given social situation. They are distinct from social norms or *perceived* social norms, which are the *actual* social consensus on a given social behavior or the individuals' perception of the existing social consensus, respectively.

Guerra et al. proposed that normative beliefs are acquired through a socialization process, which occurs with a primary caregiver, a significant reference group, and through personal evaluation [27]. First, a child's primary caregivers play an important role for their social development and have an incredible influence, especially on infants. Caregivers or parents are the usually the first source of verbalized rules, normative beliefs, and social norms, which are quickly encoded and integrated into early childhood cognition. They also contribute to the establishment of an infant's personal normative beliefs. Second, children develop normative beliefs through social exchanges with other individuals as well, such as peers, extended family members, or a significant reference group. As a child interacts within these networks of people, they can be easily influenced and may accommodate new rules, socials norms, and beliefs. Third, children construct normative beliefs that are coherent with their own evaluative schemas. Briefly, this evaluative schema contains a response evaluation, outcome expectancies, and a self-efficacy assessment [11]. Respectively, these refer to an assessment of the quality of certain morally- and value-based social responses (e.g., morally good vs. morally bad responses), to personal opinions about the results of these responses (i.e., thoughts about the consequences of these responses within the social realm), and to the degree of confidence they have in their ability to successfully perform these behaviors and achieve a particular desired outcome (i.e., an assessment of one's capacity to successfully perform a chosen social response). It has been theorized that if a child's evaluative schema is biased toward aggression and/or hostility, then they will develop normative beliefs that approve aggressive social responses. Furthermore, these aggression-related normative beliefs are thought to crystalize over time, thus promoting an increase in aggressive behavior throughout the lifespan. Indeed, it has been found that aggressive children, as compared to their non-aggressive peers,

will (1) evaluate aggressive responses more favorably [28, 29], (2) are more likely to expect a favorable outcome if physical or verbal aggression is used [30–32], and (3) feel more confident about their efficacy when performing behaviors that are physically and/or verbally aggressive [31–33].

2.5 Negative social feedbacks

There is now empirical evidence supporting the fact that environmental factors (such as witnessing acts of aggression) and emotion dysregulation (e.g., difficulty in controlling one's anger) are predicted by aggressive normative beliefs, and that these beliefs predict subsequent aggressive behavior [34]. Furthermore, children who engage in these acts of aggression may provoke aggressive tendencies in others and thus create or stimulate an aversive environment. Within this hostile atmosphere, children often exchange negative social feedback, which only serves to reinforce aggressive normative beliefs and behaviors (also referred to as a "self-fulfilling prophecy effect"). As this pattern repeats itself, it becomes of a vicious cycle of aversive environmental triggers, aggressive cognitions, and aggressive behavioral responses [35].

2.6 Executive functions and early aversive environments

Executive functions are higher order cognitive abilities that are responsible for the regulation of thoughts, emotions, and actions [36, 37]. While there are many different ways to define or describe executive functioning, it is generally thought to comprise (1) cognitive control of planning or organizing action(s), (2) monitoring a series of responses [38–40], (3) divided attention or attentional control, (4) abstract reasoning, (5) alertness, and importantly, (6) behavioral regulation or inhibition [41–43]. A recent study that used a behavioral assessment of reactive aggressive behavior (i.e., an emotion-driven impulsive act in response to a perceived threat) found that the degree to which a participant could inhibit their responses (also known in cognitive psychology as "response inhibition") was the strongest predictor of reactive aggression. This finding held when compared to other cognitive processes such as working memory, cognitive flexibility, and attentional control [43, 44]. For this reason, when examining early childhood factors that play a role in the development of aggressive behavior, we have placed an important focus on cognitive processes that relate to inhibition.

As previously mentioned, inhibition is an executive function that allows a person to inhibit a dominant response [45]. It has primarily been linked to brain function involving the prefrontal cortex (PFC). Many neurocognitive researchers have shown that child maltreatment can affect specific brain regions within fronto-limbic networks [46–50]. The implicated brain regions include the PFC, the orbitofrontal cortex, the anterior cingular cortex, and the amygdala [46, 48, 50, 51]. According to the "Interactive Specialization model" by Johnson [52], some cortical regions, which are responsible for neuronal maturation and specialization, become functionally efficient by having sufficient neural activation. It is possible that maltreatment in infancy disturbs these activations. Also, increased density of glucocorticoid receptors due to early life stress (such as maltreatment in infancy) is theorized to negatively affect the early maturation of the PFC [53].

2.7 Inhibition and the social environment

Numerous studies have demonstrated that impaired inhibitory control interacts with the cognitive functions involved in processing social information. More

specifically, both the interpretation and response decision steps have been linked to deficits in inhibitory control, which predicts aggressive behavior [54–58]. Difficulties in inhibiting hostile schemas may lead children to habitually interpret others' behavior as being hostile (hostile attribution bias), and low inhibitory control increases the probability of choosing the most salient and dominant response (e.g., behavioral aggression).

From an evolutionary-developmental perspective, low inhibitory control is not necessarily considered as an impairment in cognitive function, but rather a form of adaptation amidst an unstable environment [59, 60]. For example, one study found that individuals who grow up in harsh and unpredictable environments (e.g., dangerous, crime-ridden neighborhoods) prefer smaller immediate rewards over larger future rewards [61]. In other words, within dangerous and unstable environments, a preference for immediate rewards may be more adaptive than a preference for delayed rewards in an uncertain future [62]. From this perspective, inhibition would be an inefficient function, as it prevents people from taking advantage of immediate benefits [63]. Therefore, it is possible that early childhood adversity decreases inhibitory control in order to help a child better adapt to particular environments, which may explain the relationship between low inhibitory control, uninhibited aggressive behaviors, and early adverse social experiences.

Taken together, a solid literature links early social adversity in childhood to aggression, and this happens through socio-cognitive mediators such as aggressive schemas, normative beliefs that support aggression, and low inhibitory control. It is important to note, however, that childhood adversity is one of *many* risk factors related to aggressive behavior, and adverse social experiences in early age does not necessarily lead to aggressive behavior in adulthood. In the following section, we will discuss other contributing social factors, how they interact with cognitive and neurobiological function, and how they may serve to maintain aggressive behavior over time.

3. Underlying factors that perpetuate impulsive aggression in adulthood

3.1 The neural substrates of impulsive aggression

In most social contexts, even those involving a conflict or altercation, an impulsively aggressive act can result in unnecessary harm, serious injury, and even death [64, 65]. Having the ability to implement and execute context-appropriate regulation strategies will play an important role in shaping how a person will react to stressors or unpredictable situations later in life. As previously mentioned, human neuro-behavioral functioning is not *solely* influenced by early-life situational factors. *Individual differences* in genetic disposition, cognitive ability and flexibility, emotion regulation, and behavioral inhibition, as well as many other internal and external factors, will all have major implications for a person's capacity to have healthy and adaptive interactions within the social realm.

3.2 The effects of cortical and subcortical neural imbalance

Much of what we presently know regarding the brain-behavior dynamics of impulsive aggression was acquired from examining case studies of individuals who suffered from brain trauma, neural lesions, or brain tissue damage due to illness or disease [39]. A well-known example is that of Phineas Gage, a nineteenth century railroad worker who survived a horrific accident whereby a large iron rod pierced through his skull, destroying a large portion of his left frontal lobe. While this

tragedy resulted in deleterious effects on his personality, social relationships and general quality of life, it also served to enable ground-breaking discoveries in the domain of neural specialization and functionality. In particular, the area damaged during the accident—the PFC—was subsequently linked to the regulation of emotional states such as anger and impulsivity, as well as maladaptive behaviors, like impulsive aggression [66].

Researchers examining the link between PFC function (or cortical regions, more generally) and impulsive aggression have looked at various components of cognitive processes such as *executive functioning*. Furthermore, neurochemical imbalances in the level of the steroid hormones cortisol and testosterone, as well as fluctuations in the modulation of neurotransmitters such as serotonin, have all been shown to induce physiological changes in core affective and cognitive processing brain regions, which have an important influence on the way an individual perceives and acts in response to social threats [67].

3.3 Dysregulation of social behavior networks

The tendency to habitually respond to a perceived threat in an aggressive manner is not governed by frontal brain regions alone; rather, it is thought to be maintained by a complex interplay of cognitive, affective, and behavioral neural systems [39, 68]. Researchers examining these mechanisms in relation to impulsive aggressive urges and behaviors have proposed that a disruption in decision-making and social-emotional information processing circuits is also a key contributor [39]. From a cognitive neuroscience approach, it is posited that an imbalance in top-down control (primarily governed by prefrontal brain regions) and activity in subcortical areas responsible for "bottom-up" processes (i.e., "feed-forward" modulation of emotional, appetitive, as well as aggressive reactivity) leads to difficulties in behavioral inhibition [68]. Abnormal activation in fronto-parietal regions may enhance impulsive drives, such as the urge to respond aggressively to a social provocation [65, 69]. For example, in an examination of aggressive behavior in relation to frontal-lobe functioning, Giancola and Zeichner used neuropsychological measures to test young men in a social-provocation paradigm [42]. Results indicated that men who performed poorly on the tests were significantly more aggressive toward peers, as compared to those who performed better. The researchers proposed the possibility that diminished frontal-lobe functioning coupled with provoking external conditions (e.g., social provocation) may lead to decreases in behavioral inhibition and a heightening of aggressive reactivity [42]. This finding is further validated by studies examining specific cognitive impairments linked to recurrent antisocial behavior and the tendency to reoffend in criminal populations (i.e., recidivism). A recent meta-analysis concluded that impairments in inhibition—the executive function that is particularly important for behavioral self-regulation and the suppression of dominant impulses—were a significant predictor of future acts of physical aggression and violent crime [70].

Researchers have also used functional magnetic resonance imaging (fMRI) to examine neural activity within the social behavior network in real time (i.e., in vivo). Numerous studies have replicated evidence of critical interconnections between frontal cortices, subcortical regions, and striatal brain regions in the maintenance of aggressive response patterns (for review, see [71]). The flow of activity within these connections regulates emotional processing, which acts to modulate behavioral reactivity [72, 73]. For example, in an fMRI study by Coccaro and colleagues, brain regions that have previously been linked to impulsive aggression were assessed for functional deficits [74]. Results indicated that individuals with high aggressivity (as compared to healthy controls) showed greater activation in

the amygdala—a subcortical brain structure thought to play a key role in emotional processing, threat detection, and in activating stress-induced behavioral response [74–76]. Inversely, healthy controls showed greater activation in frontal regions when viewing the emotional faces [74]. Similarly, Nomura [77] found that healthy participants who viewed emotional images showed an inverse functional connectivity between the amygdala and brain regions thought to be responsible for integrating affective information, emotional valuation, and decision-making processes. By contrast, individuals who met criteria for intermittent explosive disorder (a psychiatric disorder characterized by emotional dysregulation and pathological impulsive aggression) failed to show such functional connectivity [71, 77]. The results suggest that individuals who have difficulty regulating emotions and inhibiting aggressive impulses may have impaired connectivity in the cortico-limbic pathway [71].

3.4 The influence of emotional reactivity within the social sphere

More recently, researchers have investigated the neural substrates of impulsive aggression in relation to social situations that provoke negative emotional reactivity (e.g., feelings of anger or hostility, betrayal, jealousy, social exclusion or peer rejection; [78, 79]). In addition to the importance of past social experiences, it has been suggested that rejection is one of the *most common precursors* of aggression and one of the *most significant risk factors* for adolescent violence [79, 80]. After an incidence of social rejection, studies have shown that people fail to process situational information in an efficient and adaptive manner, which leads to reductions in self-control [81].

The question of why some individuals respond to particular social exchanges by increasing their efforts to gain acceptance or reconcile a conflict, while other individuals tend to respond with increased aggression and acts of retaliation, is an area of research that is still being explored. One such investigation, by Chester and colleagues tested whether social rejection triggered aggressive reactivity through heightened activation in areas of the brain associated with emotional pain or anger. They further assessed whether individual differences in executive functioning moderated this relationship [73]. Findings were consistent with socio-cognitive models positing that for some individuals, social rejection triggers negative emotional responses such as anger, which may lead to maladaptive cognitive appraisals and deficits in decision-making strategies, thus triggering the impulse to act aggressively [13]. Similarly, in a study that included healthy female and male participants, Achterberg and colleagues investigated aggressive feelings and behaviors in relation to negative social feedback [82]. Conjunction neuroimaging findings from the study found greater activation in the right dorsal lateral PFC during negative feedback (as compared to neutral feedback), which was significantly associated with shorter noise blasts (an index of lower levels of aggression) in response to negative evaluations from peers. The results suggest that particular areas within the PFC factor into the regulation of affective impulsive actions, such as socially provoked aggression [82].

3.5 Social information-processing mechanisms

Pioneered by developmental researchers, such as Crick and Dodge [11], major advances in our understanding of social behavior more generally have emerged from studies on social cognition and social adjustment during childhood [83–85]. Over the last few decades, the social information-processing model (SIP; [11]) has been extensively researched. It has paved the way for a better understanding of how social cognitive constructs formed early in childhood can perpetuate a cycle of

maladaptive behavioral response patterns throughout the lifespan [25, 86]. Indeed, a considerable amount of evidence has supported a significant relationship between deficits or difficulties in social cognitive processing and higher levels of aggressive response patterns during social interactions [87, 88].

The general SIP model [11] (here, adapted for adults) proposes that when a person enters a social situation, they are already primed with a set of biologically determined cognitive capacities and a history of social experiences that are stored in long-term memory. Amidst an array of social cues, their ensuing behavioral response is thought to be a function of how they have processed those cues. In a sequential manner, it is hypothesized that the person begins the social interaction by selectively attending to cues on both an internal level (e.g., related to affective or cognitive processes) and external level (i.e., related to situational/environmental stimuli). After encoding the cues, the person interprets them according to a number of evaluative processes. They may filter the information in accordance to their own personalized knowledge structures (i.e., mental representations that are based on similar social scenarios from previous experiences). They may also make inferences and attribute intentions to the person(s) involved in the interaction, and evaluate how they handled similar social exchanges in the past. Next, they determine whether or not the strategies they used in the past were successful in achieving the goal(s) that they had set out to obtain. Depending on how they perceive their self-efficacy (i.e., self-assessment of past performance) and the degree to which they deem past strategies successful, they form predictions or expectations about the outcome of using a similar strategy in the current situation [11].

After interpreting the situation, the person then proceeds by clarifying their goals, while taking into consideration their desired outcome (e.g., settling a previous dispute, taking revenge for a past offense, asserting a sense of control or power, etc.). This evaluation is thought to be highly influenced by the person's present state of arousal, which acts to orientate them toward achieving their goal. It is also at this step that a person may revise their goals or find different strategies that may be more appropriate to the current situation. In some circumstances, a quick response is necessary and it may be more feasible to construct a new response strategy or readjust their outcome expectations. According to the SIP model, once a response has been selected, the behavioral enactment ensues. However, a person may have difficulty or deficits in regulating the intensity of their affective arousal. If the person is unable or unwilling to select or produce an adaptive response, then it is likely that impulsive urges will interrupt the decision-making process and cognitive control mechanisms. As is often the case with impulsive aggressive acts, when a breakdown in inhibitory control occurs, withholding a potentially maladaptive response may prove to be difficult or unattainable [89].

3.6 Integrating information-processing theories with complex dynamical models

When factoring in that many social interactions involve a number of uncertainties and ambiguities (e.g., knowledge of the motivations or perceptions of the other parties involved), it can be challenging to quickly process, generate, refine, and select an appropriate behavioral response. For this reason, many information-processing (IP) models have been criticized for the rigidity of their linear structure and lack of complexity in explaining *actual* brain function and activity (e.g., mechanistic explanations of dynamic neural systems, contingent features, nonlinear connectivity as it happens in *real time*, etc.; [11]). Despite these shortcomings, IP paradigms clearly have a heuristic value and one of the most effective applications

of their principles are in providing a basic understanding of how active social cognitive processes may contribute to emotional and behavioral reactivity.

Since its original conception, the SIP model has been reformulated to reflect a more complex, cyclical process, whereby multiple cognitive processes may occur simultaneously and operate in a time-related sequence [11]. Some reformulated IP models have made the distinction between information that is processed "online" (working representations gathered from the immediate environment) and information that is processed "offline" (knowledge structures stored in long-term memory; [25]). The online representations are hypothesized to contain information from social cues that are encoded during the onset of interaction. Here, particular emotionally charged cues may evoke attentional biases that facilitate hostile attributions [90]. In situations where missing or ambiguous environmental data occur, online representations are thought to be supplemented or "filled in" by information taken from stored knowledge structures [25].

This revised formulation demonstrates how *active* cognitive processes can be *directly* influenced by previous social interactions. With repetition, these processes may be conditioned over time, and thus serve as a control mechanism for a variety of impulsive behaviors [11, 91, 92]. Indeed, if a person regularly evokes a particular knowledge structure (e.g., "Social encounters are inherently hostile"), then "offline" information (e.g., "When someone gives me a dirty look, it means I need to watch my back") may repeatedly find its way into a person's "online" representations ("They're giving me *that look*. I won't let them be the first to attack").

Notably, personal motivations and expectations regarding social interaction are multi-factorial. Furthermore, a person's baseline affect (i.e., their current emotional state) will play a critical role, both in *how* the person is likely to interpret a particular social situation and *what* they are likely to "select" as a response. Despite the multitude of factors that may contribute to the maintenance of impulsive aggression, one of the primary goals of this chapter is to examine and integrate evidence-based knowledge on the control mechanisms involved so that a better understanding may facilitate effective interventions.

4. Adaptation of inhibitory-control training in the treatment of impulsive aggression

Although an impulsive response that is aggressive in nature may appear on the surface as a simple disinhibited reaction to an internal or external trigger, the studies reviewed in the previous sections invite us to develop a conception of impulsive aggression that is much wider. Here, we underline *the person* as being in constant interaction with his or her social environment during the selection, or lack thereof, of his or her behavioral responses. It is during his or her social interactions that all the active social cognitive processes which underlie aggressive behaviors are being played out. In addition, early interactions experienced in childhood are gradually transformed into cognitive structures (e.g., hostile schemas or aggressive response scripts) which reflect past experiences and continue throughout development. As a person progresses into adulthood, these cognitive structures will influence his or her emotional and psychological state and affect their responses in a given social situation. This observation leads us to the necessity of placing ICT within the social domain and to question how it may be adapted to the treatment of impulsive aggression. We will present the theoretical premises of ICT as an intervention model and compare them with those of the SIP model of impulsive aggression. Thereafter, this will allow us to identify possible options of ways to adapt ICT to the treatment of impulsive aggression.

4.1 Theoretical aspects of the ICT model of intervention and SIP model of impulsive aggression

There exist several interventions that aim to reduce aggressive behavior, from early intervention in children [93, 94] to comprehensive programs for nonclinical adults [95, 96], to programs specific to individuals with psychopathology [97, 98]. Intervention programs are usually multimodal and are composed of an education component [93], and modules that target self-control [99], cognitive distortion modification [91], emotional regulation strategies [100], and the involvement of a person's environment [93]. For its part, with the aim of reducing behaviors that may be harmful to a person's health, ICT has taken place within the context of appetitive behaviors such as abusive relationships with food or eating [101], alcohol [102], drugs [103], and tobacco [104]. For some individuals, these behaviors have a significant reward value [105]. Although not specifically aimed at aggressive behavior, ICT targets behaviors that share a common basis with aggressive behavior. Indeed, appetitive behaviors [105] and aggressive impulsive behaviors [106] are characterized by a deficit of inhibitory control. It is therefore reasonable to believe that ICT can serve as a complementary module to interventions that are usually offered for the treatment of impulsive aggression.

ICT refers to a category of interventions in the form of cognitive training which uses computer-based tasks, such as the stop-signal task or the go/no-go task, which requires motor control functions to either restrain an action or cancel an ongoing action [107]. This training aims to increase inhibitory control skills that regulate appetitive behaviors. It is postulated that obesity and substance abuse are caused both by a hyper-valuation of an appetitive stimulus and hypo-function of inhibition mechanisms [108]. The procedure generally involves training a person to initiate an inhibition response to an external stimulus that visually represents the appetitive stimulus (i.e. unhealthy food or beer images; [109]). Meta-analysis has demonstrated a significant effect of ICT in the reduction of appetitive behaviors, as measured in a laboratory setting (ad-libitum; [105]). For some behaviors, it has been demonstrated to have generalized positive effects on the quality of a person's daily life (e.g., food intake; [110]). However, this has not been demonstrated for all behaviors (e.g., alcohol consumption; [107, 111]). This result supports the need to adapt ICT to the nature of certain impulsive behaviors. One of the mechanisms of action postulated to account for the effects of ICT is the creation of a bottom-up association between the appetitive stimulus and the inhibitory response that bypasses the need for a more general inhibitory control [101, 112].

Although inhibitory control is an important part of the intervention to reduce impulsive aggression behavior, several determinants are not accounted for within an ICT-based intervention model. At the level of situational determinants, the aggressive response may occur as a result of an external stimulus, such as a social provocation, but it may also occur as a result of an internal stimulus. Internal stimuli include the person's cognitions and emotions. Among cognitive determinants, for instance, when following an ambiguous social provocation, the interpretation that the other person has hostile intentions can lead to aggressive behavior [85]. Among emotional determinants, anger is well known as an internal state that can lead to reactive aggression [113]. However, it can be claimed that many other negative affective states, such as anxiety [114] or sadness [115], can also serve as an internal trigger for aggression. It has been observed that certain thoughts or strong emotions can affect the information processes of a person in a social situation [90]. The person's processing of information becomes incomplete or erroneous, and this increases the risk that the person will respond aggressively [116]. Moreover, negative feedback from the social environment in response to aggressive behavior can

maintain those erroneous cognitions and intensify the negative affect of the aggressive person [13]. Interventions resulting from the SIP model are therefore intended to improve the accuracy and depth of a person's information processing ability. It also actively integrates the person's environment, which enriches positive social experiences that will ultimately change the way the person perceives the world and processes social information [117]. **Table 1** summarizes the main theoretical differences between the ICT and the SIP model of aggression.

4.2 Two-person neuropsychology

In terms of their theoretical premises, the ICT model and the SIP model may seem, at first glance, to be incompatible. However, we believe that it is possible to adapt ICT-based interventions to include the social domain. With this aim, we propose a novel approach to intervention for impulsive aggression, and consider a perspective based on two-person neuropsychology. Inspired by the two-person psychology approach, we will use the expression "two-person neuropsychology" in two ways. First, it refers to the idea that impulsive aggression occurs in the social domain and that neuropsychological interventions should aim to improve social information processes. The second meaning pertains to the transformation of cognitive structures within an individual with impulsive aggression, which we believe *requires* input from the other. According to SIP models of aggression, a distinction is made between two distinct components—"online situation-specific" and "offline person-specific" [117]. With "two-person neuropsychology," the first part would involve interventions that target the cognitive processes which take place in specific social situations, whereas the second part refers to interventions which target stable cognitive structures of the person.

4.3 Implementation intention strategy in support of ICT on cognitive processes

For individuals who are habitually aggressive, it has been shown that their social information cognitive processing is dysfunctional and influenced by erroneous cognitive structures [118]. In other words, the information being processed is

	ICT model	**SIP model**
Postulated causal mechanisms	Hyper-valuation of appetitive stimulus, stimulus reward and reward sensitivity Temporary lessening of inhibition function, which increases in response to an appetitive stimulus	Incomplete or erroneous social information processing Hostile cognitive structures that may interact with deficient executive functions (which include inhibition)
Triggers	External stimulus (i.e. smelling and/or viewing food or alcohol)	External (i.e., social provocation) and internal (i.e., negative affective state, such as anger) stimulus
Behavioral Maintenance Factors	Reward value of the appetitive stimulus	Negative social feedback
Postulated mechanisms of action	Top-down inhibitory control skill Automatic bottom-up association (stimulus-stop) Devaluation of stimulus, which follows the inhibition of stimulus	More accurate and in-depth social information processing Positive social feedback from appropriate social interactions

Table 1.
Comparison between the ICT and the SIP model of aggression.

largely based on pre-existing cognitive structures rather than on actual cues that are present in the social situation [13]. These structures lead to an automatic processing of the situation, which prevents the person from processing other relevant information which may be helpful in deciding the appropriate course of action in a given social situation [16]. Therefore, there is a link between a social situation and a cognitive process that appears conditioned by past experiences [119]. For example, a person who has been exposed to hostile situations in different social contexts during his or her development will be inclined to encode hostile information to the detriment of other non-hostile cues. Over time, this process becomes spontaneous and automatic [12]. For this reason, we believe that it is necessary to *disengage* the aggressive person from his erroneous cognitive processes, and help him or her to develop new associations between the same social situation and a new cognitive process. Given that ICT uses an external stimulus, and the automatic response which is targeted during training involves motor function, we recommended finding a comparable therapeutic strategy that would broaden ICT intervention targets. We feel that implementation intentions can serve this purpose. "Implementation intentions" is a self-regulation strategy that aims to help a person achieve their goal by implementing a series of behavioral steps. This includes (1) ensuring that behaviors are put in place in a specific situation, (2) these behaviors are designed to help the person achieve a desired goal which is planned in advance, and (3) the behaviors should take place automatically as soon as the situation is met [120–123]. This technique is based on an "if-then" contingency, where "if" represents the situation and "then" represents the response. The advantage of implementation intentions in relation to ICT is that the situation can be both external and internal, and the response can be modified and improved at any stage in the cognitive processing of social information. Also, this technique does not require lengthy training. For the most part, the focus is on verbalization and visualization of a plan. During these verbalization/visualization sessions, the person determines precisely all the elements of the situation which afford an opportunity to execute the plan. They also determine how they will act or respond cognitively in this particular situation. This strategy makes it possible to create new associations between a stimulus and a response, and in this respect, it appears compatible with one of the postulated mechanisms of action of ICT (e.g., creation of automatic bottom-up association). This association circumvents the necessity to make use of a general inhibitory control skill because the will of the person is delegated to the situation. Once established, such an association happens automatically (or quickly), efficiently, and without awareness. Also, because it is determined and planned in advance, the "if-then" plan represents an action restraint in which the decision to inhibit is made from the onset. As such, it is not an action cancelation, whereby the decision to inhibit occurs *after* implementation of the dominant response. This allows for cognitive processes to be similar to those running during a go/no-go task—the task that appears to be the most effective among ICT tasks [124].

4.4 Adaptation of ICT applied to impulsive aggression

Applied to impulsive aggression, the first step in implementing intentions would be to make an assessment of the person who is impulsively aggressive, and determine whether there are steps in the cognitive processing of social information which may be contributing to their aggressive behaviors. Subsequently, one can imagine that it is possible to plan if-then-type strategies for the step that is in question. Given that erroneous cognitive processing related to impulsive aggression mostly concerns the first steps in SIP [116, 117], the following discussion will be applied to the encoding, interpreting, and goal selecting processes.

Imagine the following social situation: you are at work and you receive a comment from one of your colleagues about your work. Based on an ICT model of intervention, this (or a similar situation) could make use of computer tasks during the training phase. At the level of the encoding step, the task could be similar to a dot-probe task [125], which is often used in research to measure attentional biases toward hostile cues in an aggressive person. The task is to present a pair of faces (both hostile and neutral) above and below a central point, which is followed by an arrow that points to the right or left in the upper or lower part of the screen. After viewing the presented cue, the person must indicate as quickly as possible in which direction the arrow was pointing. A hostile attentional bias is characterized by a shorter reaction time for arrows that appear where an angry face was presented, as compared to where a neutral face was presented. With the help of implementation intentions, a person might want to develop an if-then plan to encode more non-hostile cues into a situation where they receive feedback from a colleague. This plan would aim to create a new association between "a colleague made a comment about my work" and the attention directed toward non-hostile cues, such as "my colleague's facial expression." More specifically, during the training with the dot-probe task, the implementation intentions would aim at encoding non-hostile faces such as, "When the pair of faces appears on the screen, I will only pay attention to the neutral face." Such training could be generalized thereafter to real-life situations (e.g., "When my colleague makes a comment about my work, I will try to pay attention to his facial expression and see if he is *actually* criticizing me").

At the level of interpretation, the task could be an adaption of the "Hostile Expectancy Violation Paradigm" [126, 127], which involves a written scenario containing initial sentences that are used to establish a hostile versus non-hostile context, during which a character simultaneously commits an ambiguous behavior directed at the reader. These sentences are then followed with a third sentence that ends with a word informing the reader of the nature of the character's underlying intention for his or her behavior. The person would then be asked to guess the intention of the character before the presentation of the last word. Following a non-hostile context, a hostile interpretation of the character's ambiguous behavior would indicate a hostile attributional bias. With the help of implementation intentions, a person might want to develop a plan in order to interpret a colleague's comment about their work in a non-hostile manner. More specifically, during the training with the Hostile Expectancy Violation Paradigm, the implementation intentions would aim at interpreting non-hostile intention behind behaviors such as "When I read the intention sentence in which the last word reveals the intention of the character, I will think about a word that refers to a non-hostile intention". Again, such a training could be generalized thereafter to real-life situations (e.g., "When my colleague makes a comment about my work, I will try to think that my colleague did not make the comment with malicious intent").

Finally, in terms of goal selection and the emotions that accompany it, one can imagine that ideally, the plan is that the person does not act aggressively before the negative emotion has lessened. With the help of implementation intentions, a person might want to develop a plan to stop an impulsive behavior while experiencing a strong negative emotion. More specifically, during the training with the Hostile Expectancy Violation Paradigm (or other similar scenarios whereby a person could be asked to imagine his or her emotional response following a social provocation), the implementation intentions would aim to execute alternative behaviors to anger outbursts, such as "When I read the social provocation and I imagine that I feel anger toward the character, I will stop my reaction, breathe deeply and assess my

level of anger. I will continue breathing or leave the place if my anger is still high." Again, such training could be generalized to real-life situations (e.g., "When my colleague makes a comment about my work, I will stop my reaction, breathe, assess my anger on a scale, and then wait until my anger has diminished before responding to my colleague").

4.5 Long-term interventions on hostile cognitive structures

We end this section with interventions that target the cognitive structures of aggressive individuals. We believe that only positive interactions with others or mid- to long-term psychotherapy can gradually change these relatively stable cognitive structures. In addition to cognitive therapy [128], several psychotherapy approaches have been proven effective in helping aggressive persons via the transformation of their mental structures. In order to prevent an impulsive behavioral response to an unconditioned experienced emotion, some interventions are designed to help individuals with mental elaboration (symbolization) of the emotional experience instead of acting out the emotion. The mental elaboration of the emotional experience makes the experience more tolerable and facilitates the development of more complex cognitive structures [129]. Other approaches aim to make individuals aware of their inner relational world, which influences their perceptions of people and the way they feel and relate to them [130]. When considering all the factors that are at play in an individual's mental life, we discover a multitude of social motivations that can contribute to acts of aggression, as well as psychological issues that may be associated with these behaviors [131]. A better self-awareness of these motivations and psychological issues could help aggressive persons transform their social cognitive structures. Finally, it is recommended that these interventions be accompanied by the development of positive relationships in real life. Marriage, family, or interpersonal therapies can support this goal, and new positive social interactions and relationships are expected to help change existing maladaptive hostile cognitive structures.

5. Conclusion

We have demonstrated the importance of social determinants in the development of hostile cognitive structures and the lack of inhibition in children. We have also demonstrated the cerebral connectivity underlying aggression in adults and its influence on the processing of social information. This has prompted us to want to adapt ICT and incorporate social cognition into its scope, which has thus far remained limited to the domain of motor control. We have proposed that implementation intentions strategy represents an intervention that is promising in achieving this goal. We believe that ICT adapted to the social field represents a promising therapeutic avenue to help people who suffer from impulsive aggression. However, this chapter is only a first step in this direction. We hope that this chapter can shed light on the issue of ICT in the treatment of impulsive aggression, and that it can stimulate both a theoretical debate and the realization of empirical study on the effectiveness of ICT in the treatment of impulsive aggression. On a daily basis, humans are in continual interaction with each other. There is little doubt that society would greatly benefit from interventions that are based on a better understanding of how internal knowledge structures serve as cognitive control mechanisms that perpetuate a cycle of impulsively aggressive behaviors.

Author details

J. Gagnon[1,2,3]*, J.E. Quansah[1,2,3] and W.S. Kim[1,2,3]

1 Department of Psychology, University of Montréal, Canada

2 Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR), Montreal, Canada

3 Laboratoire d'Électrophysiologie en Neuroscience Sociale (LENS), Department of Psychology, University of Montreal, Canada

*Address all correspondence to: jean.gagnon@umontreal.ca

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