Behavioral Activity and Tic Disorder

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Previous approaches to functional assessment of tic and habit disorders have centred largely around environmental contingencies or interceptive sensory processes as positive reinforcers. The current article argues rather that ongoing telic behavioral activity is functionally linked to tic onset and so type of behavioral activity and overall action plan at the time of ticcing should also be assessed. Evidence is presented from past studies in support of a link between tic location and type of activity and the way this activity is appraised. It is further proposed that intervention strategies for reversing tic habits should include a more holistic behavioral restructuring of muscle use rather than just an exclusive focus on developing antagonistic muscle actions as competing responses.

Keywords: tic disorder, habit disorders, habit reversal, holistic behavioural restructuring, antagonistic muscle actions

Behavioral Treatments for Tic Disorders

Recent studies have shown that behavior therapy (BT) can be successfully applied to the management of Tourette's syndrome (TS), tic and habit disorders (O'Connor, 2005). The results rival those achieved with medication and given the problems of compliance with medication and the perils of neuroleptic use with children (Peterson & Azrin, 1993), behavioural programs could in theory become the treatment of choice for these disorders. But despite small scale studies showing successful outcome in a range of tic subtypes (Peterson & Azrin, 1992), behavioural treatments are far from being accepted in psychiatry as a mainstream intervention. Clinician consensus strongly favours a neurobiological model of treatment with psycho-education and eclectic supportive counselling as an adjunct (Peterson & Cohen, 1998). A contributing reason for the lack of acceptance by clinicians of behavioural analysis and therapy may be the lack of a convincing model of behavioral processes operating in tic aetiology.

Behavioral Principles and Behavioral Process in Tics

Whereas most BT methods naturally espouse behavioral principles, the techniques appeal to a number of diverse behavioral mechanisms, some in apparent contradiction to one another. For example, the technique of "massed practice" which has shown some early success (Feldman & Werry, 1966), attempts to negatively reinforce ticcing through building up reciprocal inhibition, whilst techniques of relaxation emphasize lowering tension rather than increasing it, also with apparent success (Bergin, Waranch, Brown, Carson, & Singer, 1998). Conversely, exposure and response prevention would encourage tolerating the urge to tic without either tensing or relaxing the tic affected muscle group (Verdellen, Keijsers, Cath, & Hoogduin, 2004).

Other behavioral intervention strategies have relied more or less exclusively on different aspects of contingency management to control tics. But even here the contingencies vary considerably and can include environmental, social or attentional task demand (Miltenberger, Fuqua, & Woods, 1998). Hence the theoretical considerations driving functional analysis in BT may often be in conflict, and may hamper development of a standard model of managing behavioural processes in tics. Although there is consensus that tics and habit disorders are auto-reinforced, there is disagreement as to the role of negative versus positive automatic reinforcement contingencies. For example, some authors report social reinforcement
as a key maintaining factor (Watson & Sterling, 1998) whilst others report lack of attentional state as a precursor (Roane, Piazza, Cercone, & Grados, 2002). So, applying time out to negatively reinforce ticcing within a social reinforcement model may conflict with according additional attention to positively reinforce task engagement as a means of reducing tic frequency. As Miltenberger et al. (1998) have noted, the paucity of systematic behavioural and functional analysis of tic behaviour means that little is known about the function of behaviours treated with BT.

Indeed, the most successful behavioural package to date, “habit reversal” (HR) (Azrin & Nunn, 1973) includes a rationale based on several mechanisms. The original multicomponent program drew on techniques derived from conditioning theory, awareness training, contingency management, motivational training, social support, symbolic rehearsal, and motor skills learning of a new motor pattern (the antagonist response) in addition to tension and stress management. The key element of HR is reversing the tic through learning an incompatible antagonist response. But even the incompatible response may serve diverse and conflicting functions, ex. strengthening of antagonist muscles, heightening awareness, counter-conditioning, operating in non-specific ways and even acting as a punishment schedule (Turpin, 1983; Miltenberger et al., 1998). The shortened versions of the HR procedure still represent conflicting rationales and their active components rely variously on: awareness training, incompatible response training and social reinforcement (Woods, Miltenberger, & Lumley, 1996).

Interestingly, the original rationale of Azrin and Nunn (1973) was more psychophysiological than behavioral, proposing that tics were adaptations of a startle or abnormal trauma reactions integrated into normal response chaining and thereafter auto-reinforced due to minimal awareness. So an upshot of this confusion over behavioral process is that there is still much debate over the actual effective components in BT for tics.

**Tic function and functional analysis**

Recently a more unified behavioural model of mechanisms driving tic onset has centred on the tension and on the heightened sensory activation occurring prior to the tic (Evers & van de Wetering, 1994). Unlike conditioning and to some degree neurobiological models, the sensori-motor model sees a positive function for tics in their release of tension. But in this model tension release is not just a positive habit reinforcer but part of a more general sensori-motor regulation. Consequently, interventions based on this model aim at either stress management and tension reduction or use an exposure and response prevention model similar to the approach designed to treat obsessional fears and ritualistic behaviour (Verdellen et al., 2004). Here the reinforcement for ticcing is essentially viewed along an intrinsic or interoceptive dimension in contrast to earlier notions of discrete external environmental reinforcers. Indeed functional analysis in tic disorders can seem one-dimensional when focused almost exclusively on ABC sequences looking for social, environmental or attentional triggers, and may arrive at individual case formulations which do not easily generalize to other cases, since they lack theoretical underpinning. Although attempts have been made within some habit disorders such as trichotillomania to provide more comprehensive, cognitive, emotional and sensory profiles (Mansueto, Goldfinger Golomb, Mc Combs Thomas, & Townsley Stemberger, 1999), there is a paucity of such approaches in tic disorders. As Forget and Otis (1980) noted, after a review of how apparent contingencies of tic behaviour can be misleading, systematic functional analysis is essential prior to intervention, and we may need a more holistic notion of the tic as a behavioral act to comprehensively assess its function and process.
The current paper argues that the optimal focus of functional and behavioral analysis for tic behaviour should be on the activity of the person at the time of ticcing rather than exclusively on environmental or interoceptive contingencies. It is further argued that characteristic sensori-motor activity may be the key trigger for ticcing, and this produces, amongst other results, chronically heightened tension and accompanying sensations as a precursor to ticcing. However, it is argued that tension by itself does not explain ticcing, but that this tension itself needs to be viewed in a wider context of a (tic disorder specific) style of motor preparation. Implications of the model for behavioral evaluation and treatment methods are illustrated.

TICCING AND TENSION

One consistent component associated with tics is muscle tension. In fact, tics can be considered a form of short-term tension regulation comparable to how obsessive compulsive rituals neutralize anxiety. Even Azrin and Nunn, in their 1973 paper, cite this tension reduction factor as a recognized component. Subsequently, Hoogduin, Verdellen, and Cath (1997) noted that tension was consistently reported in their tic patients. O’Connor, Gareau, and Borgeat (1995) reported some psychophysiological evidence for difficulty in regulating tension in tic affected muscles. The original HR program emphasized relaxation to relieve tension instead of ticcing, and even by itself, relaxation can reduce tic frequency. From a physiological point of view, tics like all reflexes require a degree of muscle contraction prior to onset. But what is muscle tension and how is it built up?

TENSION AND ACTION

Non-neuropathological muscle tension is effectively preparation for action. As such, it fits within the motor activity schema of: planning, preparation, execution and feedback of continuous movement. What is prepared, how and for how long depends on the action goal (or lack of goal). Planning coordinated action relies on the constant shifts required to effect the continuous correction of feedback and feedforward information necessary to regulate precise coordination and targeting (Kelso, 1994).

Many factors can lead preparation astray. Other pathologies besides chronic tics suffer from chronic motor tension, for example, tension is recognized as a key complaint in generalized anxiety disorder (GAD) (DSM-IV; APA, 1994). In the case of GAD, the muscle tension frequently represents preparation for an anticipated worse case scenario and the muscle tension can reduce post treatment (O’Connor, Gareau, Gaudette, & Robillard, 1999). One can also prepare for the right action but inappropriately. There is mounting evidence that people with tics and habit disorder may invest more than necessary in preparing for an action, such that the action may be impaired or inhibited. For example, more of the motor cortex lights up with a simple motor action in people with tics compared to controls (Biswal et al., 1998). Also people with tics have problems inhibiting movement and difficulties preparing for complex tasks. In addition, preparation may not be optimally linked to response execution (O’Connor et al., 2005).

STYLE OF PLANNING: DEFICIT OR STRATEGY

These results at first glance suggest problems with executive functioning, but there is no firm evidence of such blanket neuropsychological deficit. On the other hand, what we do know is that people with tics and habit disorders adopt a particular style of action characterized by
over-preparation and overactivity (O'Connor et al., 2005). This style includes planning too much activity, doing too many tasks at the same time, and over-investing in too much effort (both emotionally and physically). Although such a pattern may be considered hyperactive, it is driven not impulsively, but often compulsively by perfectionist concerns about personal image and standards. This style of action seems characteristic of tic and habit disorder and is linked with the self standards and personal organization subscale of Frost's Multi-dimensional perfectionist scale (Frost, Marten, Lahart, & Rosenblate, 1990; O'Connor, 2005).

The consequence of adopting this habitual style of action from a purely motor psychophysiology perspective is that arousal and performance regulation may be compromised or inhibited. Indeed, the most reliably reported performance problems in TS appear on motor and visuo-motor tasks (Schultz, Carter, Seahill, & Leckman, 1999); exactly where this style of planning action would most delay or impede response regulation. Conversely, simple response speed appears to be faster in TS without necessarily an accuracy trade off (O'Connor, Robert, Dubord, & Stip, 2000). So this differential effect on performance supports a strategy rather than a deficit model.

The tension reduction and learned association model of tics can come together quite nicely in an integrated model proposing that a tension producing style of action elicits inappropriate tension and preparation which then leads on to ticcing as a means of short-term tension release (see Figure 1). So we may ask why does tension produce tics in TS and not in, say, GAD or other disorders with high tension levels. Again the answer lies in the type of preparation the tension represents. Tension in TS seems characterized by a frustration action cycle where the muscle is inappropriately prepared prior to execution. Within an activity model, the person with a tic is preparing too quickly and impatiently for an immediate response but at the same time preparing more muscles with more effort than necessary. This preparation is inappropriate so the tic action relieves in part, through local tension release, this unnecessary activation in the absence of an immediate goal. In GAD, as noted, the tension may be part of preparation in anticipation of a more distant future event, and so does not create the same immediate frustrated action cycle. If this behavioral process of inappropriate action planning precedes ticcing, then behavioral evaluation may benefit from greater focus on muscle use and ultimately background activity to identify source of tension preceding tic, and hopefully then alleviate it.

![Activity-tension tic cycle diagram](image-url)

**Fig. 1. Activity-tension tic cycle.**
Functional analysis and situational variability

As noted earlier, there have been few attempts to systematically apply functional analysis to tics, and most such analyses have been conducted in line with behavioral principles that assume environmental contingencies. But people with tics do show a high and low risk profiles, and clinicians have for sometime noted anecdotally that, for example, ticcing is less likely when the person is engaged in a task (Leckman & Cohen, 1999).

The circumstances eliciting tics and habits can be characterized according to the overall state (low mood) or situations (or anticipations about situations) in which the person finds themselves. Christensen, Ristvedt, and Mackenzie (1993) noted a series of emotional precursors to the onset of hair pulling. Azrin and Nunn (1977) recognized that different strategies need to be applied in the use of competing responses depending on different situations. Several authors have noted that tics and habits are elicited by negative states, including depression, lack of self-worth and boredom (Dean, Nelson, & Moss, 1992).

In a series of studies examining situational variables, O'Connor, Gareau, and Blowers (1993, 1994) initially monitored high, medium and low risk situations in 13 clients with tics and found that all clients showed high, medium and low risk situation profiles linked to tic onset, but that these profiles showed little consistency across clients. High-risk situations could be either arousing or relaxing situations, ex. one client was most likely to tic when arguing, another when relaxing at home in front of the TV. However, this situational blurring was clarified when considering evaluations associated with the situations, since the thoughts and feelings accompanying tic onset, regardless of situation, most frequently concerned impatience, frustration and not performing as desired. Furthermore, even planning to enter a high risk tic situation could by itself elicit the tic and constitute a high risk activity, suggesting a strong potential role of preparation in tic production.

In subsequent clinic work, we realized that recording activity level was more parsimonious that seeking situational contingencies. For example, the same two people could be in front of the television but one thinking of all the housework to be done, the other following the television program. So not only activity level but also action plan (that is what the person was planning to do in any given situation) seemed important to consider when creating tic related profiles. Driving for one person could be a relaxing break from routine but for another, stressful if he or she had planned to make the journey as fast as possible. Previous functional analysis has tended to ignore activity as a tic trigger.

Several studies have suggested that tics, in particular phonic tics, might be contingent on activities rather than stimulus conditions. Roane et al. (2002) explored a number of reinforcement contingencies and cues for a young man's verbal tic including: environmental factors, when alone, task demand, play, automatic reinforcement, preference objects and (tangible, musical, auditory, oral) stimulation. Although no external contingencies seemed associated with tic onset, naturalistic observation revealed that the tics were absent when lying down and more frequent in an upright position. The authors concluded that the tic was auto-reinforcing but did not consider the significance of lying down as a coping activity for the patient, since they were unable to determine the mechanism attenuating the tic when lying down. But the authors emphasize the limitations of analyses restricted to environmental analysis.

Carr, Taylor, Wallander, and Reiss (1996) found no stimulus contingency for a vocal tic in an 11 year old male student, except that it worsened when he was spoken to in a disapproving manner, but improved when he was involved in academic study, suggesting a role of social activity. Watson and Sterling (1998) found a vocal tic related to eating and social activity but focused rather on the social reinforcement as the principal maintaining factor rather
than the eating. Woods, Friman, and Teng (2001) reported a controlled study showing that talking, in particular about tics, increased the likelihood of vocal but not motor tics. Other case studies have anecdotally pointed to the importance of activity cues as well as environmental contingencies in single case formulations (e.g., Fuata & Griffiths, 1992; Scott, Schulman, & Hojnacki, 1994).

**Behavioral Activity Associated With Tic Onset**

In a subsequent study (O’Connor, Brisebois, Robillard, & Loiselle, 2003), we set out to examine activity profiles linked to tic onset in people suffering from chronic tics and habit disorders, and to compare these profiles amongst different subgroups of tics and habit disorders.

Seventy six people aged 18 to 62 (38 male and 38 female; mean age = 38.2, SD = 10.0; 70% with partners; mean chronicity of problems = 24.6 years, SD = 11.02) diagnosed with either chronic tic, TS, or habit disorder participated in the study. We distinguished two exclusive diagnostic categories: **Habit disorders**, encompassing hair pulling (n=15), teeth grinding (with daytime component) (n=6), skin scratching (n=4) and nail or finger biting (n=15); and **simple chronic tics**, comprising shoulder movement (n=5), head motion (n=18), and eye blinking (n=15). The participants completed with an evaluator a form ranking the three most frequent high-risk activities and the three most frequent low-risk activities cues linked to tic or habit onset. Figure 2 shows a more recently modified evaluation form.

<table>
<thead>
<tr>
<th>Description of the situation or activity</th>
<th>Goal of action plan</th>
<th>General tension level (0-5)*</th>
<th>Specific muscles contracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving the car</td>
<td>To arrive at destination as soon as possible</td>
<td>4½</td>
<td>Arms: 4, Neck: 4, Hands: 5, Shoulder: 3</td>
</tr>
</tbody>
</table>

Figure 2a  Example of assessment of high risk activity for tic onset

<table>
<thead>
<tr>
<th>Description of the situation or activity</th>
<th>Goal of action plan</th>
<th>General tension level (0-5)*</th>
<th>Specific muscles contracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watching a film</td>
<td>To be engaged in the story</td>
<td>2½</td>
<td>Eyes: 3, Neck: 3, Face: 2</td>
</tr>
</tbody>
</table>

Figure 2b  Example of assessment of low risk activity for tic onset

**Classification of activities**

The individual reports on the high- and low-risk activities had enough characteristics in common to enable them to be regrouped into the 12 activity categories (study activity, intellectual work, grooming, manual work, passive attendance, eating, relaxing, leisure pursuits, socialization, sport activity, in transit, waiting for an appointment). The same categorization was used for both high- and low-risk activities. Each activity was allocated to one category. A
small proportion of the activities (8 out of 456) did not fit into any of these categories and so were not included in the analysis. The test-retest reliability of the categorization assessed at two points, two months apart, was 1.00. The initial category sorting was replicated by an independent rater. Inter-rater agreement tests conducted on a subset comprising 15 subjects yielded kappa values ranging from 0.60 (p<.02) to 1.00 (p<.00).

Study referred to activity where the goal was to study, and the activity was to selectively acquire knowledge or information. Passive attendance referred to activity involving watching or listening in the role of a spectator, but not as active learner or participant. Physical exercise applied when the goal of the activity was engaging in sport or exercise activity. Relaxation was a category reserved for resting or lying, or sitting down for the express purpose of relaxing. Socialization involved active interpersonal or group contact within a formal or informal social occasion, such as interacting with others at a social setting or a party. The goal of grooming behavior was self-care, including showering, washing, brushing teeth, combing hair. Leisure activity involved active pleasant pastimes such as engaging hobbies. Waiting was a classification which applied when the person was actively waiting for an appointment or an event where waiting was the main purpose. In transit applied where the principal goal was to travel between places or appointments. Manual work involved achieving a material goal through physical effort. Intellectual work involved the active pursuit of an intellectual occupation or profession. Eating behavior was classified where the specific goal at the time of the tic or habit onset was to eat. Obviously, there were some borderline categorizations. For example, was eating out with a group of friends, social or eating activity? Was a job involving active listening and processing information (working in a complaints department or as a counsellor) active study or intellectual work? But the boundary disputes were generally resolved by consensus amongst raters based on an understanding of the principal goal of activity at the time of tic onset. If there was no consensus, the item was eliminated.

A two-way chi-square compared the presence or absence of activity types in high- and low-risk categories between the two tic/habit disorder groups. Separate analyses were conducted for low- and high-risk activities. If the overall chi-square was significant, the adjusted residuals (non-parametric equivalent of z-scores) for the cell percentage of each subgroup were examined. An adjusted residual score greater than 1.96 for a given subgroup percentage indicated that the subgroup differed significantly from the overall group percentage.

Table 1. Summary of findings relating tic and habit onset to behavioral activity.

<table>
<thead>
<tr>
<th>Activity type</th>
<th>High risk tic/habit onset</th>
<th>Low risk tic/habit onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social activities (party, social occasion)</td>
<td>Eye / face / mouth tics</td>
<td>Hair pulling, nail biting, skin scratching</td>
</tr>
<tr>
<td>Manual work (digging, holding, operating machine)</td>
<td>Shoulder / upper arm tics</td>
<td>Other complex habits</td>
</tr>
<tr>
<td>Passive listening / relaxing doing nothing</td>
<td>Nail biting, scratching</td>
<td>Eye blinks</td>
</tr>
<tr>
<td>Active study or intellectual activity</td>
<td>Hair pulling, nail biting</td>
<td>Head / eye tics</td>
</tr>
</tbody>
</table>


A summary of significant results is given in Table 1. For nail biting and hair pulling, tic habits were mostly recorded during study or active listening activities, whereas eye blinks and
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head tics were generally absent during both study or active listening and passive listening tasks. Conversely, eye tics were more likely during social occasions whereas hair pulling was less likely during social interactions. Shoulder tics were more likely during manual work and less likely during passive listening. But relaxation was a high risk activity for scratching. Interestingly, eating was a low risk activity for scratching tics.

We also elicited appraisals related to the high- and low-risk activities which were classified into nine constructs: active-inactive; calm-tense; satisfied-dissatisfied; interest-bored; in control-not in control; judged-not judged; energized-tired; and open-reserved. Again, a few entries (5 out of 311) did not belong in any construct category and were omitted. Inter-rater agreement was measured for all categories, again using 15 subjects; kappa values were between 0.53 (p<.04) and 1.00 (p<.00) (see Figure 3).

The tense/relaxed construct seemed the most relevant to the manifestation of both tic/habit disorders. A tense state was associated with onset of the disorder in 64 out of 76, or 84% of participants. A high-risk activity was most likely to be appraised as active and as tense by those with simple tics, in particular eye and head tics, while appraisal of a high-risk activity as inactive was most likely in habit disorder (nail biting, hair pulling, scratching). In particular, appraisals of boredom were associated with a high risk of hair pulling and scratching, but were likely not to constitute a high-risk appraisal for people with a head movement tic. The appraisal of a high-risk activity as unsatisfying was made by 88% of people with head tics and 67% with teeth grinding, and 48% of all other participants.

### Table

<table>
<thead>
<tr>
<th>Activities</th>
<th>Feelings about or evaluations of low risk activities (1-3)</th>
<th>Feelings about or evaluations of high risk activities (5-7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1  Reading in bed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2  Watching television</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3  Singing alone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4  Playing competitive sport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5  Driving my car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6  Arguing my point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High risk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Likelihood of tic absent**  
- Calm  
- Confident

**Likelihood of tic present**  
- Preoccupied  
- Insecure

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**Implications of the behavioral activity analysis**

This study demonstrated the existence of an idiosyncratic pattern of high- and low-risk behavioral activities for individuals with tic and habit disorder. Moreover, there were also
consistent differences in profile between habit disorders and tics. Further analyses indicated that habit disorders (especially hair pulling, scratching and nail biting) shared common activity profiles, which distinguished them from eye tics. Manual work activity was associated with head movements, shoulder movements and teeth grinding. Hair pulling was associated with intellectual activity and onset of eye tics seemed to occur more during socialization. Some of the habit disorders were cued by boredom and somebody with the hands unoccupied may, of course, be more likely to perform a manual habit, just due to occasion. On the other hand, the physical location of the tic did seem to have some functional connection with the ongoing activity. Face tics were more likely during socialization where the task demand focus is often on the face. Shoulder tics were more associated with work activities where strain on the arm and shoulder is likely. Since an hypothesized immediate result of ticcing is a temporary relief of tension in the specific implicated muscle groups, it may be reasonable to suppose that habitual activities influence distribution of tension and hence determine the local development of tension-releasing tic habits.

Elaboration of the activity model

The current analysis of activity then goes beyond the tension reduction motive of the sensorimotor regulation model to suggest that tics are not just learnt responses auto-reinforced by sensory or tension release, but that their location and occurrence depends on background behavioral context; above all activity level and telic action plan. If the person blinks excessively in a social activity, or burps repetitively when eating, or moves the legs up and down continuously when studying, then clearly the tic needs to be considered in a wider behavioral context and not just as an isolated response.

Tic onset occurs against a general background of chronic tension. The tic onsets in one group of muscles since the muscle implicated in the tic seems linked to muscle usage within a precise activity and action plan. Although in TS tics can move around the body, this fact would still support the activity model as long as the tic occurs in muscles linked to a precise action-frustration cycle, and the tics occur in voluntary muscles linked by usage or by expression to a high risk tic activity. Sometimes the functional link between a person's activity, goal and tic location and development is self-evident. For example, a masseuse develops a twitch in her most forceful dominant hand when she is trying to rush a massage, a trombone player develops a tic in his lips, mouth and tongue during a hasty rehearsal. In other cases the link may be indirect and more symbolical. Take for example the case of a person who grimaces and makes a sound like “tsk tsk” with her mouth when anticipating problems. The sound and movement resemble an expression of negative self-judgement and frustration and so represent a symbolic link with her main activity which is in this case "evaluating the problem."

The tic-affected muscle might be implicated in an expression of emotion or action adapted for use in the high-risk situation or activity. For example, a client with an eye tic whose style of action involves always speaking forcefully and over-involving face and cheek muscles in speech, feels he must fixate his addressee in order to not miss information in an encounter. He considers quick blinking an asset to help communicate in interpersonal encounters. So the tic action may serve part of a more general behavioral purpose and be linked to cognitive as well as physical goals. Obviously a defensive or startle reaction, as proposed by the Azrin and Nunn (1973) learning model, would count as one such purpose, but only as one example and not a "universal" category of tic associated activity. Tics may also become incidentally associated with a goal directed movement through erroneous learning. A person may blink with the cheek muscles rather than just the eyelids or study putting tension in the legs, so leading to a leg twitch.
At first sight, it might appear that this link with muscle use applies selectively to certain complex tics which are more clearly purposeful, but not to more simple tics. But the activity model would hold that all tics occur as part of an action plan. Of course, tension may be present in muscles irrelevant to the task, as long as they are activated by the task demand. In all cases, the tic would be activated by sustained chronic preparation in the service of an identifiable activity.

**Clinical implications**

In clinical terms, intervention strategies could optimally address reversing the habit not so much from an isolated antagonistic action point of view, but from a general behavioral restructuring point of view, touching on reorganizing preparation, planning and coping in high risk tic situations. Such restructuring might initially be inspired by looking at how the person prepares and organizes action during low risk activities. For example, opening the eyes wide while softly blinking as a competing response to eye blinking (Miltenberger, Fuqua, & McKinley, 1985) could be contextualized as a behaviour permitting more social contact. Maintaining an upright chin and tensing neck muscles in a forward direction to counteract a head and shoulder tic could be integrated into a more goal-directed and possibly more economical set of movements involving a redistribution of tension in preparation for a manual task. In part, such restructuring is already sometimes carried out under the guise of habit reversal strategies and it has been previously noted that competing responses do not always need to be anatomically antagonistic to the tic muscle (Verdellen et al., 2004). There have also been direct attempts at modifying overall behavioral activity as a means of tic control, for example, Lamontagne (1978) reported that modifying social behavior through increased social exposure reduced tic onset, in particular vocal tics. Paquin (1977) reported a decrease in ticcing through use of imagined mastery scenarios of tic situations, and Clarke, Bray, and Kehle (2001) combined self-modelling and feedback of self-behavior with HR to reinforce adoption of competing responses.

The impact then of a behavioral analysis focusing more on activity level, and the goal or plan of the action is to give a clearer functional link between overall behavioral activity, tension and tic function. Such analysis provides a more comprehensive and hence acceptable and expedient way to eliminate the tic through overall behavioral restructuring as opposed to the HR rationale of searching for isolated antagonistic responses which are not always obvious or socially acceptable.

The model also accounts for how tics may apparently substitute and interchange in TS according to activity (Seligman, 1991) and how some tics appear to be "contingentless" using conventional functional analysis focusing on environmental factors, and also how, for example, simply changing activity or engaging attentionally within the same social or stressful environment can reduce or enhance tic activity. The activity model integrates tension reduction and sensori-motor regulation models with learned association accounts of tic aetiology as well as potentially accounting for the few consistent neuropsychological findings of apparent visuo-motor impairment in TS.

**Conclusion**

Essentially a learned behavioral strategy involving over-activity and over-preparation leads to the development of inappropriate tension in localized muscles during specific activities. The behavioral strategy leads to frustration and inappropriate motor preparation which is relieved by ticcing but which in turn, in the long run, reinforces sensori-motor
dysregulation. The tic behavior may also be auto-reinforced by environmental and other contingencies and by limited awareness. But in particular the cycle might be reinforced by further behavioral coping strategies such as tensing or camouflaging or avoidance or other safety behaviors.

The activity model also offers several avenues to pursue further for its validation or disconfirmation. The model would predict that: a) all tics would be consistently linked to some activities and not others; b) the activities in question would directly or indirectly involve inappropriate tension in tic affected muscles; c) modifying overall behavioral style of planning through behavioral restructuring would decrease tension and hence the likelihood of tic onset and also beneficially affect other aspects of sensori-motor dysregulation in tic disorders.

References


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