Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

The Cognitive Heterogeneity of Obsessive-Compulsive Checking

Sanaâ Belayachi, Martial Van der Linden

University of Liège, Belgium University of Geneva, Switzerland

KEYWORDS: obsessive-compulsive disorder; checking; heterogeneity; action processing

ABSTRACT

The present article reviews the phenomenology of obsessive-compulsive checking, examining how action processing can be differentially affected across distinct checking subtypes. Checking is a normal phenomenon which ensures that an intended goal has been actually completed. Checking symptoms have consistently been connected to impairments in processing information related to self-performances. Theoretical and empirical work has explained compulsive checking as a result of various cognitive deficits related to action processing (e.g., low confidence in cognitive abilities, impaired memory for actions, abnormal reality monitoring, overactive action monitoring, defective goal processing). Such apparent inconsistencies are, however, in agreement with clinical and empirical observations highlighting substantial variability in the subjective experience preceding/accompanying checking. Many factors can in fact prevent the cognitive system from determining whether or not an intended goal has actually been achieved. We argue that several action processing mechanisms are likely affected in checking; the related subjective experience may vary accordingly.

Repeated checking is well known in the context of obsessive-compulsive disorder (OCD). According to the classical conceptualization of OCD, obsessive-compulsive (OC) phenomena are characterized by both obsessions and compulsions. Obsessions are defined as recurrent unwanted intrusive thoughts or images that provoke distress/ anxiety, generally related to threatening events. In response to obsessions, patients with OCD may perform mental or physical acts in a repeated or stereotyped way, known as compulsions, with the hypothesized purpose of avoiding negative events evoked in prior obsessive thoughts. This conceptualization of OC phenomena does not, however, account for the entire complexity of the clinical reality, which points to substantial heterogeneity in the factors underlying the various OC phenomena. Currently, researchers agree on the existence of several OC dimensions (e.g., checking, repeating, washing, ordering, hoarding, counting, magical/neutralizing rituals) that imply distinct pathogenic mechanisms (e.g., Mataix-Cols et al., 2004; McKay et al., 2004; Murayama et al., 2013). Furthermore, it appears that distinguishing various OC dimensions according to their behavioral manifestations is not sufficient to understand the mechanisms underlying OC phenomena because heterogeneity within OC dimensions has also been reported (Rasmussen & Eisen, 2002), particularly regarding checking

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

(Ecker & Conner, 2008; Pinto et al., 2007; Tolin, Brady, & Hannan, 2008). In this article, we review the various checking subtypes, identifying cognitive mechanisms that may underlie each checking subtype.

CHECKING SUBTYPES

Both theoretical and empirical work suggests that there are different subtypes of checking, which can be distinguished according to the related core motivational and emotional features (Ecker & Conner, 2008; Pinto et al., 2007; Rasmussen & Eisen, 2002; Summerfeldt, 2004; Tolin et al., 2008). In the following section, we focus on three checking subtypes which can be distinguished at both phenomenological and cognitive levels.

PATHOLOGICAL DOUBT-RELATED CHECKING

Pathological doubt about the properties of a stimulus, situation, or action seems to be a core feature of checking phenomena (Rasmussen & Eisen, 2002). In the case of actions, an individual performs an action and then experiences persistent doubts about its effective completion. For example, a person may experience persistent doubt about whether or not he or she turned off the stove completely; in response to this worry, he or she may interrupt his or her ongoing behavior and check the stove to make sure it is off. In this context, checking implies the interruption of a current action to check the completion of past actions.

INCOMPLETENESS-RELATED CHECKING

Checkers can experience incompleteness feelings as immediate impressions of failure or imperfection or sensations that "something is wrong" with an action or the environment (Coles, Heimberg, Frost, & Steketee, 2005; Summerfeldt, 2004), which can lead to an inability to achieve a sense of task completion or "closure" regarding actions (e.g., locking the door) or perceptions (e.g., objects on a table). In the particular case of action incompleteness, people may experience feelings that "actions or intentions have been incompletely achieved" or feel only a weak sense of goal satisfaction, despite the obvious achievement of the goal. The characteristic peculiar sense of dissatisfaction (i.e., a feeling that something is wrong) in this case occurs during action completion, preventing checkers from experiencing an immediate sense of task completion. It can affect a wide range of routine and basic actions (e.g., reading, hair brushing, putting socks). People feel that "something is wrong" with an ongoing action, but they may also have difficulty identifying what it is and consequently check and repeat these actions until they get the feeling that things are "just right" (e.g., Summerfeldt, 2004).

CHECKING RELATED TO AN INFLATED SENSE OF RESPONSIBILITY

In agreement with the classical conceptualization of OC phenomena according to which compulsive behaviors aim to prevent a harmful event, compulsive checking has been widely related to an inflated sense of responsibility for preventing harm to oneself or others (Salkovskis, 1985). Inflated responsibility can be defined as a strong tendency to foresee potential future threatening events. The classical view of OCD suggests that prior obsessive thoughts which contain images or thoughts

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

related to negative outcomes may trigger the strong conviction that something bad is about to happen and that not preventing it is as bad as doing it. People encountering this experience of responsibility may develop a kind of hypervigilance for preventable threats and start to check safety-related actions (e.g., turning off a stove, locking the door, closing a window) to make sure that they are preventing foreseen harmful events (Rhéaume, Ladouceur, Freeston, & Letarte, 1995; Salkovskis, Shafran, Rachman, & Freeston, 1999).

COGNITIVE ACCOUNTS OF CHECKING

There thus exists a wide range of distinct checking phenomena. For instance, some patients check their past actions because they doubt whether their intended actions have been actually or properly done (i.e., pathological doubt-related checking). Others experience peculiar feelings that "something is wrong" with a recent action or its results and check and repeat it until they get the "just right feeling" (i.e., incompleteness-related checking). Some patients check significant actions (stove, door, knife) to avoid a potential future outcome (i.e., checking related to an inflated sense of responsibility). These different checking subtypes might be sustained by distinct and possibly overlapping cognitive mechanisms. Most studies attempting to understand the mechanisms underlying checking phenomena have pointed to impaired processing of self-performed actions at various levels of the cognitive system. Among the numerous studies on cognition and checking behaviors, however, very few have taken the heterogeneity of checking into account, although some authors have attempted to make theoretical connections between their findings and some of the features that figure in the different checking types. The following paragraphs review the most significant cognitive accounts of checking and attempt to link specific cognitive dysfunctions to particular checking features (Figure 1).

COGNITIVE PROCESSING OF PAST ACTIONS

MEMORY FOR ACTIONS

One of the most influential assumptions regarding defective action processing in checking suggests that people may check because they are unable to register and/or retrieve a memory trace of their past actions. Some studies have indeed found checking-prone individuals to show poorer memory performances for their past motor actions (Ecker & Engelkamp, 1995; Rubenstein, Peynircioglu, Chambless, & Pigott, 1993; Sher, Frost, Kushner, Crews, & Alexander, 1989; Zermatten, Van der Linden, Laroi, & Ceschi, 2006).

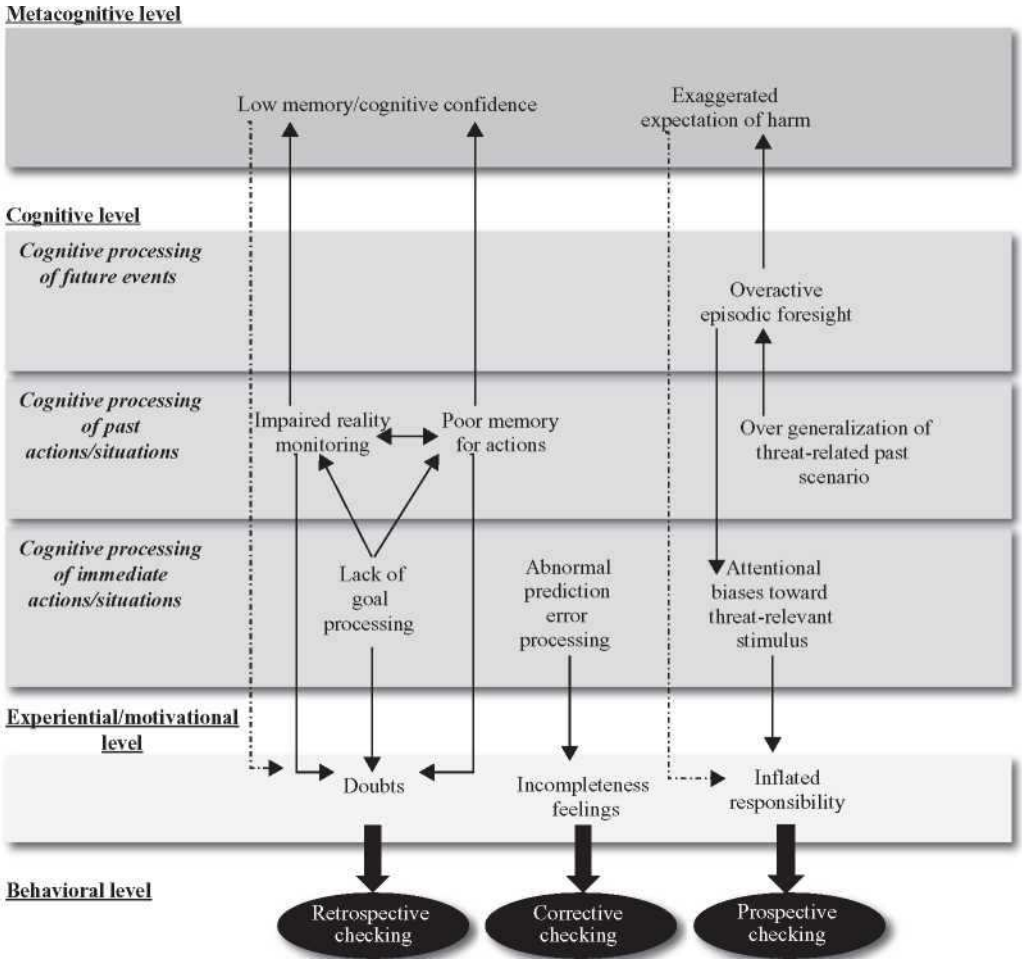
REALITY MONITORING

Some results suggest that checking is also connected with greater difficulty determining whether memories represent a really performed action or an imagined action (e.g., Ecker & Engelkamp, 1995; Zermatten et al., 2006). A memory trace of turning off the stove may be available to checkers, for example, but they may be unable to determine whether they actually turned off the stove or only imagined doing so. Our ability to distinguish real from imagined events depends mostly on the richness of various phenomenal features of the memory trace (Johnson, 1988): The more detailed

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

and vivid the memory, the more it will be identified as a memory of a real event. In this vein, some studies have examined the phenomenal characteristics of checkers' memories of past actions compared to those of nonchecking controls.

FIGURE 1. *A schema for the cognitive heterogeneity model of checking. Continuous arrows refer to potential direct effect, whereas discontinuous arrows refer to hypothesized indirect contributing factors.*



Such studies have found checkers' memories of past actions to contain fewer visual and kinesthetic details (Zermatten & Van der Linden, 2008; Zermatten, Van der Linden, D'Argembeau, & Ceschi, 2008), to be less vivid (Zermatten & Van der Linden, 2008; Zermatten et al., 2008), and to be more impersonal (i.e., checkers experienced themselves as an observer rather than the actor of their actions during remembering; Zermatten et al., 2008). It has been hypothesized that the fact that

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

checking people remember their actions from an observer perspective and with few kinesthetic information may underlie doubts about whether an action has been performed or just imagined (i.e., defective reality monitoring) and the ensuing checking behaviors.

COGNITIVE CONFIDENCE

Other studies have failed to find support for the hypotheses that checking results from memory deficits (e.g., Moritz, Ruhe, Jelinek, & Naber, 2009) or defective reality monitoring (e.g., Merckelbach & Wessel, 2000). Based on these inconsistent results, some authors have suggested that checkers may not suffer from memory disturbances per se but from memory *distrust,* leading to the same functional consequences as the absence of memory traces (e.g., Hermans, Martens, De Cort, Pieters, & Eelen, 2003). This hypothesis of low confidence has been interpreted as consistent with the fact that checkers doubt their own cognitive abilities in general, including not only their ability to remember but also their perception and attentional capacities (Hermans et al., 2008).

Several authors have proposed, in contrast, that defective memory, poor phenomenological memory features, impaired reality monitoring, and memory distrust may all stem from the checking propensity. On this view, it is the fact that actions are repeated either behaviorally or mentally that affects mnemonic characteristics and confidence (e.g., Hermans et al., 2008; van den Hout & Kindt, 2003, 2004), leading checkers into a vicious cycle in which distrusted memory triggers checking, but the checking itself leads to weak and unreliable memory as well as a decrease in memory confidence. The problem with this conception of checking is that although it offers a possible explanation of cognitive deficits consecutive to checking, it does not explain the mechanism through which people first start to check.

To sum up, empirical examinations of past action processing in checking have led to mixed results. The divergent results of the earlier mentioned studies could stem from the fact that none of them took the heterogeneity of checking into account. Only two studies have incorporated phenomenological features into their examination of memory function and confidence in checking. These studies revealed that impaired reality monitoring (Olson et al., 2016), impaired memory function (Zitterl et al., 2001), and memory distrust (Zitterl et al., 2001) in checking are specifically connected with pathological doubt. It thus seems that whether or not deficits in processing past actions are observed depends on the extent to which checking in the study population is connected with doubt about action completion. It is also worth noting that the different hypotheses on past action processing described earlier may not be mutually exclusive. Memory for actions, reality monitoring, and memory confidence are interconnected cognitive components, and it is possible that one reported deficit could be in fact a side effect of another deficit. For example, it has been suggested that poor reality monitoring in checking might be secondary to motor memory deficit: The latter would lead checking people to have less precise and distinctive memory traces of actions, which might in turn result in a difficulty deciding whether the action was really performed or just imagined (Zermatten et al., 2006). Similarly, it is possible that reported low memory confidence in checking may be in fact the long-term consequence of less efficient memory for action/ reality monitoring. Indeed, theoretical and empirical work suggests that information accessibility/availability is a major factor contributing to cognitive confidence (e.g., Cleeremans,

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

Timmermans, & Pasquali, 2007). In that context, an impaired ability to create proper memory traces of past actions along with the awareness that one has difficulties in accessing memory details would lead to the general belief that one's memory is not efficient. On the other hand, it has been demonstrated that checking patients diminished checking behaviors and had better memory performances after a psychological intervention targeting metacognitive beliefs concerning one's memory functioning (Alcolado & Radomsky, 2015). Although psychological intervention on metacognitive beliefs was in fact a significant predictor of decreased checking behaviors but not of increased memory performances. It should also be noted that other studies failed to demonstrate any effect of psychological intervention aimed to improve cognitive confidence on improved memory performances (FitzGerald, Nedeljkovic, Moulding, & Kyrios, 2011) and on decreased checking behaviors (Jennings, Nedeljkovic, & Moulding, 2011). These divergent results could suggest not only that cognitive confidence is in fact an indirect factor contributing to checking behaviors but also that metacognition could be an influencing factor for some, but not all, doubt-related checkers. The heterogeneity of checking should be thus taken systematically in consideration when examining the issue of past action processing to clarify the interconnections between all of the deficits reported in different studies.

COGNITIVE PROCESSING OF IMMEDIATE ACTIONS

Another line of research suggests that some checking-related features are the consequence of defective action processing during performance. Impairments in online action processing may affect several aspects of the action control system, such as action representation, comparisons between real actions and intended actions or outcomes, and so forth.

PREDICTION ERROR PROCESSING

During action performance, the cognitive system ensures that the ongoing action is contributing to goal satisfaction by making predictions about features of the action and its outcomes and comparing them to signals carrying information about the action's actual characteristics and effects. Discrepancies between predictions and the actual action context lead to error signals (i.e., prediction errors), which trigger behavioral adjustments (action correction). Error signals are not conscious as long as the system is capable of correcting action plans and predictions to ensure goal satisfaction (automatic adjustments in the case of minor discrepancies), whereas large discrepancies lead to the conscious detection of error signals to trigger controlled behavioral adjustments.

It has been suggested that checking behavior may result from permanent feelings of errors during action completion, possibly because of disturbances in the system responsible for performance evaluation (i.e., action monitoring; Pitman, 1987). Consistent with this idea, numerous neuroimaging and electrophysiological studies have reported higher brain activity during online performance in checkers, suggesting close (and thus possibly overactive) action monitoring (e.g., Hajcak & Simons, 2002; Murayama et al., 2013). On this hypothesis, checkers' overactive monitoring leads to a persistent "error signal" which triggers the need for immediate adjustment behaviors, even with correct responses. In other words, according to this hypothesis, the cognitive system

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

triggers an unjustified error signal in the absence of actual errors.

Recently, overactive action monitoring has been interpreted as reflecting increased awareness of minor error signals, which in turn disturb individuals' subjective experience of their own actions (Belayachi & Van der Linden, 2016b; Gentsch, Schütz-Bosbach, Endrass, & Kathmann, 2012). Normally, enactment implies numerous automatic adjustments (e.g., action corrections, action plan updates) because humans act in a constantly changing situation (environmental changes, body position changes, etc.). The motor control system signals the need for changes by sending error signals when predictions do not match the current state (Wolpert, Ghahramani, & Jordan, 1995). Numerous studies have shown that people are generally not aware of such corrective behaviors as long as the motor system is capable of generating automatic action corrections to reach an intended goal (e.g., Farrer et al., 2008; Fourneret & Jeannerod, 1998; Slachevsky et al., 2001).

A recent study examined action awareness in checkers with a high propensity to experience incompleteness and immediate error feelings in everyday life (Belayachi & Van der Linden, 2016b). To do this, the authors used the pointing task developed by Fourneret and Jeannerod (1998) which consists in asking participants to draw a sagittal line to a visual target with a stylus on a tablet. Participants could only see the trajectory of the stylus as a line on a computer screen, which was superimposed on (and occluded) the hand movement. On some trials, a directional bias (to the right or to the left) was introduced, so that the visible trajectory no longer corresponded to that of the hand. To reach the target, participants had to move their hand in a direction opposite to the bias. The importance of bias varied across trials, ranging from 5° (small discrepancy trials) to 20° (high discrepancy trials). At the end of each trial, they were asked in which direction they thought their hand had moved by indicating the line corresponding to their estimated direction on a screen presenting lines oriented in different directions. The authors observed that checking participants with high levels of incompleteness feelings showed greater and more rapid awareness of movement corrections, in comparison both to a checking group with a low level of incompleteness feelings and to a nonchecking control group. These results suggest that incompleteness-related checking is characterized by increased error awareness, which appears for very small discrepancies between intended and actual actions, as compared to nonchecking participants. These findings are consistent with another study which offered evidence that incompleteness feelings may be because of an impaired sensory gating (Gentsch et al., 2012) of prediction error signals that are normally not supposed to enter into the conscious stream.

DEFECTIVE GOAL PROCESSING

Other studies suggest that checkers fail to process some of their basic actions in terms of goal-related features (the "goal demotion" hypothesis; Boyer & Liénard, 2006). They suggest that during action completion, checkers may focus on information that does not allow direct assessment of whether an intended goal has been achieved (e.g., focusing on fine motor parameters rather than overall action outcomes) and that this may produce a need to take corrective behaviors to ensure that the related goal has been achieved (e.g., checking behaviors). The goal directedness of any habitual action causes it to be mentally represented with strong links between a goal and the instrumental features that serve it and to be monitored in relationship to the goal. Such goal-based

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

action processing allows people to assess how far they are from a desired end state, with few resources needed. In contrast, performing habitual actions not regarding goal-related features has been related to action disorganization and doubts about action completion (Vallacher & Wegner, 1989).

Empirical work supports the view that OCD symptoms are connected with an impaired ability to process actions regarding abstract features, such as goal and outcomes. For example, patients with OCD have been found to have an impaired ability to understand biological movements in terms of intentions and goals (Jung et al., 2009; Kim et al., 2008). In keeping with this idea, checking-prone individuals have been found to have a tendency to process various familiar actions mainly in terms of their procedural aspects and motor components rather than the related goals/outcomes (Belayachi & Van der Linden, 2009, 2015). However, another study revealed that impaired goal processing in checking depends in fact on anxiety and not on checking per se (i.e., checking individuals with low levels of anxiety do not show impaired goal processing; Jamnadass, Badcock, & Maybery, 2014). Here again, however, none of these studies took the heterogeneity of checking into account. In this vein, a recent study was conducted to investigate the applicability of the goal processing deficit hypothesis in various checking subtypes identified by means of cluster analyses (Belayachi & Van der Linden, 2016a). The results showed that goal processing deficits may be involved in a subtype of checking that is not connected to inflated sense of responsibility, dysfunctional beliefs about mistakes, or incompleteness feelings.

FUTURE PERSPECTIVES AND CLINICAL IMPLICATIONS

As we have seen, then, there are various subtypes of checking. Depending on the predominant phenomenological characteristic of a given case of checking, it is apparently possible to identify distinct underlying cognitive mechanisms. Existing findings point to the idea that pathological doubts accompany checking that is mainly because of impaired cognitive processing of past actions (defective motor memory/reality monitoring/memory distrust). For instance, some people may experience doubts about whether an intended action has been actually completed; the ensuing checking behaviors would be driven by defective memory for those actions. However, doubts about action completion have also been connected to defective goal processing during action completion. Preliminary data further suggest that impaired goal processing during performance may be specifically related to doubts about action completion in checking. Further studies are needed to investigate the connections between defective goal processing and the cognitive processing of past actions in doubt-related checking. Indeed, one could argue that an impaired ability to process goal-related information during action performance might consequently impair how these actions are stored in memory because it has been suggested that the extent to which episodes are encoded in terms of goal-related information may determine the richness of the resulting memory (Conway, 2001). It is possible, then, by training doubt-related checkers to process their actions in terms of goal-related features (e.g., by focusing attention on action-effect-related features), to reduce doubts about goal satisfaction and increase memory richness. Some data also suggest that targeting metacognitive beliefs about memory could help reducing checking behaviors (Alcolado & Radomsky, 2015). In their study, the authors trained doubt-related checking people to develop

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

evidences that their memory is not as bad as they believe by an explicit comparison of beliefs about memory and actual memory performances (e.g., systematic recording of prediction about the final state of an object before checking ["I think the light is still on"] and the outcome after checking ["In fact, the light was off"]). Participants completed several measures before and after psychological intervention, including a visuospatial memory test. The results showed that inducing an explicit monitoring of one's memory performances in checking patients did predict reduced low memory confidence scores as well as reduced number of checking behaviors but did not predict better scores on the visuospatial memory test. These results thus suggest that cognitive confidence is not directly connected with actual memory performances, although it may help reducing the need to check. Hence, knowing that acting on cognitive functioning-related beliefs helps reducing checking propensity, we could imagine therapeutic strategies targeting both cognitive factors hypothetically directly implicated in the need to check as well as metacognitive factors which could help strengthening therapeutic efficiency.

There is also empirical evidence suggesting that incompleteness feelings may involve abnormalities in online action processing (increased prediction error processing). In incompleteness-related checking, people experience an immediate feeling of error within the current action situation and consequently engage in checking and action repetition until their abnormal awareness of some action-related internal signals disappears (the "just right" feeling). Such abnormal action control-related signals might stem from increased activity observed in anterior cingulate cortex and motor (supplementary motor area [SMA]) and premotor cortices (Greenberg et al., 2000; Mantovani et al., 2006; Yücel et al., 2007). Interestingly, studies on motor control show that these regions may play a key role in the detection of sensorimotor mismatches, generally at an unconscious level (e.g., Yomogida et al., 2010). It might be that hyperactivity in these regions leads to conscious detection of those mismatch signals during action evaluation, in turn driving conscious behavioral adjustments (i.e., checking/repeating behaviors). In line with this idea, it has been demonstrated that decreasing motor cortex excitability through low- frequency transcranial magnetic stimulation specifically reduces feelings of incompleteness, but not harm-related symptoms, in patients with OCD (Greenberg et al., 2000; Mantovani et al., 2013). Transcranial magnetic stimulation, which is a noninvasive therapeutic method, might be able to serve as a tool for attenuating incompleteness-related checking.

Finally, few studies have investigated the cognitive mechanisms connected with inflated sense of responsibility. It is worth examining the possible role of mechanisms underlying future-oriented thinking in this checking subtype, given the increased tendency to involuntarily anticipate negative future scenarios, either in connection with one's own actions or with random events (because these individuals see the world as a very dangerous place). Taking an evolutionary perspective on OCD, Brüne (2006) proposed that some of the phenomenological characteristics of OCD might involve a dysfunction in an important tool for self-preservation, namely episodic foresight. Nevertheless, to our knowledge, no study has examined such mechanisms in OCD. Future studies are needed to examine the mechanisms and phenomenological features (e.g., vividness, amount of details, feeling of preexperiencing) that may specifically characterize danger anticipation in this checking subtype related to increased sense of responsibility for foreseen negative events. If responsibility-related

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

checking is indeed characterized by an overactive episodic foresight, then interesting clinical avenues could be outlined, knowing that some noninvasive methods have been demonstrated to strongly interfere with episodic foresight-related components. For example, it has been recently demonstrated that asking participants to visually track lateral continuous dot movements while generating future scenarios disturbs the episodic foresight, especially regarding the richness of some details as well as the emotional impact of these future scenarios (de Vito, Buonocore, Bonnefon, & Della Sala, 2015). The rationale behind this is that the concurrent continuous "eye movements task" disturbs the spatial organization ability, which is a crucial cognitive component for generating a mentally coherent scene during episodic foresight. In that context, we could imagine training responsibility-related checking people to engage themselves in a left-right visual scanning in an appropriate moment whenever they feel they are mentally constructing catastrophic and distressing future scenarios. This visual scanning may benefit responsibility-related checking people by diminishing the vividness and the emotional impact of their future projections.

By and large, clinical setting should take checking heterogeneity into account by building up a tailor-made therapeutic strategy that suits the initial cognitive dysfunction. Also, it is worth noticing that one checking patient may be in fact affected by several impairments, and consequently, clinicians should first identify cognitive mechanism(s) that is/are problematic in each patient, to adapt the therapeutic strategy, for example, through combining several types of cognitive remediation. In parallel, it would be interesting to complete cognitive remediation therapies with other psychological approach to teach patients how checking behaviors can interfere with cognitive functioning (e.g., psychoeducation based on existing empirical findings; see Alcolado & Radomsky, 2015; Radomsky & Alcolado, 2010; van den Hout & Kindt, 2003).

CONCLUSION

To sum up, checking can be related to various aspects of action processing, with correspondingly distinct phenomenology. Previous research on checking phenomena, however, has failed to systematically assess this phenomenology or take the heterogeneity of checking into account. Moreover, current measures of checking mainly focus on stereotyped checking behaviors and do not grasp the checking heterogeneity. Although there are numerous measures of the various phenomenological features that may help to distinguish checking subtypes, future research should develop a clear assessment of the various subtypes of checking based on the related phenomenological (motivational and emotional) features and investigate the cognitive mechanisms that are specifically involved in distinct checking subtypes. Besides the possible co-occurrence of distinct checking symptoms, there are other checking subtypes which should be further explored, such as checking related to concern about mistakes (e.g., repeatedly checking work for typos, misspellings, and errors; checking that socks and pants are put on correctly), which is characterized by the avoidance of mistakes driven by dysfunctional beliefs about errors rather than immediate perception of mistakes or doubts.

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

REFERENCES

Alcolado, G. M., & Radomsky, A. S. (2016). A novel cognitive intervention for compulsive checking: Targeting maladaptive beliefs about memory. Journal of Behavior Therapy and Experimental Psychiatry, 53, 75-83.

Belayachi, S., & Van der Linden, M. (2009). Level of agency in sub-clinical checking. Consciousness and Cognition, 18, 293-299.

Belayachi, S., & Van der Linden, M. (2015). Exploring the parsing of dynamic action in checking proneness. Behaviour Change, 32, 93-103.

Belayachi, S., & Van der Linden, M. (2016a). Checking heterogeneity and its relationships with action identification level. Manuscript submitted for publication.

Belayachi, S., & Van der Linden, M. (2016b). Incompleteness feelings in checking are connected with an abnormal awareness of action. Manuscript in preparation.

Boyer, P., & Liénard, P. (2006). Precaution systems and ritualized behavior. Behavioral and Brain Sciences, 29, 635-641.

Brüne, M. (2006). The evolutionary psychology of obsessive-compulsive disorder: The role of cognitive metarepresentation. Perspectives in Biology and Medicine, 49, 317-329.

Cleeremans, A., Timmermans, B., & Pasquali, A. (2007). Consciousness and metarepresentation: A computational sketch. Neural Networks, 20, 1032-1039.

Coles, M. E., Heimberg, R. G., Frost, R. O., & Steketee, G. (2005). Not just right experiences and obsessive-compulsive features: Experimental and self-monitoring perspectives. Behaviour Research and Therapy, 43, 153-167.

Conway, M. A. (2001). Sensory-perceptual episodic memory and its context: Autobiographical memory. Philosophical Transactions of the Royal Society B: Biological Sciences, 356, 1375-1384.

de Vito, S., Buonocore, A., Bonnefon, J.-F., & Della Sala, S. (2015). Eye movements disrupt episodic future thinking. Memory, 23, 796-805.

Ecker, W., & Engelkamp, J. (1995). Memory for actions in obsessive-compulsive disorder. Behavioural and Cognitive Psychotherapy, 23, 349-371.

Ecker, W., & Gonner, S. (2008). Incompleteness and harm avoidance in OCD symptom dimensions. Behaviour Research and Therapy, 46, 895-904.

Farrer, C., Frey, S. H., Van Horn, J. D., Tunik, E., Turk, D., Inati, S., & Grafton, S. T. (2008). The angular gyrus computes action awareness representations. Cerebral Cortex, 18, 254-261.

FitzGerald, K., Nedeljkovic, M., Moulding, R., & Kyrios, M. (2011). The relationship between neuropsychological performance, cognitive confidence, and obsessive-compulsive phenomena: A pilot study. International Journal of Cognitive Therapy, 4, 51-65.

Fourneret, P., & Jeannerod, M. (1998). Limited conscious monitoring of motor performance in normal subjects. Neuropsychologia, 36, 1133-1140.

Gentsch, A., Schütz-Bosbach, S., Endrass, T., & Kathmann, N. (2012). Dysfunctional forward model mechanisms and aberrant sense of agency in obsessive-compulsive disorder. Biological Psychiatry, 71, 652-659.

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

Greenberg, B. D., Ziemann, U., Corâ-Locatelli, G., Harmon, A., Murphy, D. L., Keel, J. C., & Wassermann, E. M. (2000). Altered cortical excitability in obsessive-compulsive disorder. Neurology, 54, 142-147.

Hajcak, G., & Simons, R. F. (2002). Error-related brain activity in obsessive-compulsive undergraduates. Psychiatry Research, 110, 63-72.

Hermans, D., Engelen, U., Grouwels, L., Joos, E., Lemmens, J., & Pieters, G. (2008). Cognitive confidence in obsessive-compulsive disorder: Distrusting perception, attention and memory. Behaviour Research and Therapy, 46, 98-113.

Hermans, D., Martens, K., De Cort, K., Pieters, G., & Eelen, P. (2003). Reality monitoring and metacognitive beliefs related to cognitive confidence in obsessive-compulsive disorder. Behaviour Research and Therapy, 41, 383-401.

Jamnadass, E. S., Badcock, J. C., & Maybery, M. T (2014). Subclinical checking is associated with a bias towards goal-directed (high-level) action identification. Journal of Obsessive-Compulsive and Related Disorders, 3, 1-5.

Jennings, H., Nedeljkovic, M., & Moulding, R. (2011). The influence of confidence in memory on checking behaviours. Sensoria, 7, 9-16.

Johnson, M. K. (1988). Reality monitoring: An experimental phenomenological approach. Journal of Experimental Psychology: General, 117, 390-394.

Jung, W. H., Gu, B.-M., Kang, D.-H., Park, J.-Y., Yoo, S. Y., Choi, C.-H., . Kwon, J. S. (2009). BOLD response during visual perception of biological motion in obsessive-compulsive disorder: An fMRI study using the dynamic point-light animation paradigm. European Archives of Psychiatry and Clinical Neuroscience, 259, 46-54.

Kim, J., Blake, R., Park, S., Shin, Y.-W., Kang, D.-H., & Kwon, J. S. (2008). Selective impairment in visual perception of biological motion in obsessive-compulsive disorder. Depression and Anxiety, 25, E15-E25.

Mantovani, A., Lisanby, S. H., Pieraccini, F., Ulivelli, M., Castrogiovanni, P., & Rossi, S. (2006). Repetitive transcranial magnetic stimulation (rTMS) in the treatment of obsessive-compulsive disorder (OCD) and Tourette's syndrome (TS). The International Journal of Neuropsychopharmacology, 9, 95-100.

Mantovani, A., Rossi, S., Bassi, B. D., Simpson, H. B., Fallon, B. A., & Lisanby, S. H. (2013). Modulation of motor cortex excitability in obsessive-compulsive disorder: An exploratory study on the relations of neurophysiology measures with clinical outcome. Psychiatry Research, 210, 1026-1032.

Mataix-Cols, D., Wooderson, S., Lawrence, N., Brammer, M. J., Speckens, A., & Phillips, M. L. (2004). Distinct neural correlates of washing, checking, and hoarding symptom dimensions in obsessivecompulsive disorder. Archives of General Psychiatry, 61, 564-576.

McKay, D., Abramowitz, J. S., Calamari, J. E., Kyrios, M., Radomsky, A., Sookman, D., . Wilhelm, S. (2004). A critical evaluation of obsessive-compulsive disorder subtypes: Symptoms versus mechanisms. Clinical Psychology Review, 24, 283-313.

Merckelbach, H., & Wessel, I. (2000). Memory for actions and dissociation in obsessive-compulsive disorder. The Journal of Nervous and Mental Disease, 188, 846-848.

Moritz, S., Ruhe, C., Jelinek, L., & Naber, D. (2009). No deficits in nonverbal memory, metamemory and internal as well as external source memory in obsessive-compulsive disorder (OCD). Behaviour Research and Therapy, 47, 308-315.

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

Murayama, K., Nakao, T., Sanematsu, H., Okada, K., Yoshiura, T., Tomita, M., .Kanba, S. (2013). Differential neural network of checking versus washing symptoms in obsessive-compulsive disorder. Progress in Neuro-Psychopharmacology & Biological Psychiatry, 40, 160-166.

Olson, C. A., Hale, L. R., Hamilton, N., Powell, J. N., Martin, L. E., & Savage, C. R. (2016). Altered source memory retrieval is associated with pathological doubt in obsessive-compulsive disorder. Behavioural Brain Research, 296, 53-60.

Pinto, A., Eisen, J. L., Mancebo, M. C., Greenberg, B. D., Stout, R. L., & Rasmussen, S. A. (2007). Taboo thoughts and doubt/checking: A refinement of the factor structure for obsessive-compulsive disorder symptoms. Psychiatry Research, 151, 255-258.

Pitman, R. K. (1987). A cybernetic model of obsessive-compulsive psychopathology. Comprehensive Psychiatry, 28, 334-343.

Radomsky, A. S., & Alcolado, G. M. (2010). Don't even think about checking: Mental checking causes memory distrust. Journal of Behavior Therapy and Experimental Psychiatry, 41, 345-351.

Rasmussen, S. A., & Eisen, J. L. (2002). The course and clinical features of obsessive-compulsive disorder. In K. L. Davis, D. Charney, J. T Coyle, & C. Nemeroff (Eds.), Neuropsychopharmacology: A fifth generation of progress. Philadelphia, PA: Lippincott Williams & Wilkins.

Rhéaume, J., Ladouceur, R., Freeston, M. H., & Letarte, H. (1995). Inflated responsibility in obsessive compulsive disorder: Validation of an operational definition. Behaviour Research and Therapy, 33, 159-169.

Rubenstein, C. S., Peynircioglu, Z. F., Chambless, D. L., & Pigott, T A. (1993). Memory in sub-clinical obsessive-compulsive checkers. Behaviour Research and Therapy, 31, 759-765.

Salkovskis, P. M. (1985). Obsessional-compulsive problems: A cognitive-behavioural analysis. Behaviour Research and Therapy, 23, 571-583.

Salkovskis, P. M., Shafran, R., Rachman, S., & Freeston, M. H. (1999). Multiple pathways to inflated responsibility beliefs in obsessional problems: Possible origins and implications for therapy and research. Behaviour Research and Therapy, 37, 1055-1072.

Sher, K. J., Frost, R. O., Kushner, M., Crews, T M., & Alexander, J. E. (1989). Memory deficits in compulsive checkers: Replication and extension in a clinical sample. Behaviour Research and Therapy, 27, 65-69.

Slachevsky, A., Pillon, B., Fourneret, P., Pradat-Diehl, P., Jeannerod, M., & Dubois, B. (2001). Preserved adjustment but impaired awareness in a sensory-motor conflict following prefrontal lesions. Journal of Cognitive Neuroscience, 13, 332-340.

Summerfeldt, L. J. (2004). Understanding and treating incompleteness in obsessive-compulsive disorder. Journal of Clinical Psychology, 60, 1155-1168.

Tolin, D. F., Brady, R. E., & Hannan, S. (2008). Obsessional beliefs and symptoms of obsessivecompulsive disorder in a clinical sample. Journal of Psychopathology and Behavioral Assessment, 30, 31-42.

Vallacher, R. R., & Wegner, D. M. (1989). Levels of personal agency: Individual variation in action identification. Journal of Personality and Social Psychology, 57, 660-671.

van den Hout, M., & Kindt, M. (2003). Repeated checking causes memory distrust. Behaviour Research and Therapy, 41, 301-316.

van den Hout, M., & Kindt, M. (2004). Obsessive-compulsive disorder and the paradoxical effects of

Published in : Journal of Cognitive Education and Psychology (2017), vol. 16, n°1, pp. 9-22
DOI: 10.1891/1945-8959.16.1.9
Status : Postprint (Author's version)

perseverative behaviour on experienced uncertainty. Journal of Behavior Therapy and Experimental Psychiatry, 35, 165-181.

Wolpert, D. M., Ghahramani, Z., & Jordan, M. I. (1995). An internal model for sensorimotor integration. Science, 269, 1880-1882.

Yomogida, Y., Sugiura, M., Sassa, Y., Wakusawa, K., Sekiguchi, A., Fukushima, A., . Kawashima, R. (2010). The neural basis of agency: An fMRI study. NeuroImage, 50, 198-207.

Yücel, M., Harrison, B. J., Wood, S. J., Fornito, A., Wellard, R. M., Pujol, J., . Pantelis, C. (2007). Functional and biochemical alterations of the medial frontal cortex in obsessive-compulsive disorder. Archives of General Psychiatry, 64, 946-955.

Zermatten, A., & Van der Linden, M. (2008). Phenomenal characteristics of memories of daily actions in checking-prone individuals. Applied Cognitive Psychology, 22, 1099-1112.

Zermatten, A., Van der Linden, M., D'Argembeau, A., & Ceschi, G. (2008). Phenomenal characteristics of autobiographical memories and imagined events in sub-clinical obsessive-compulsive checkers. Applied Cognitive Psychology, 22, 113-125.

Zermatten, A., Van der Linden, M., Laroi, F., & Ceschi, G. (2006). Reality monitoring and motor memory in checking-prone individuals. Journal of Anxiety Disorders, 20, 580-596.

Zitterl, W., Urban, C., Linzmayer, L., Aigner, M., Demal, U., Semler, B., & Zitterl-Eglseer, K. (2001). Memory deficits in patients with DSM-IV obsessive-compulsive disorder. Psychopathology, 34, 113-117.