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Time perception deficits in impulsivity disorders: A systematic review☆,☆☆

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ABSTRACT

This systematic review aims to identify evidences of distortions in time perception (TP) in people with impulsivity disorders or other conditions having impulsivity traits, namely traumatic brain injuries, certain personality disorders, addictive behavior disorders, and pathological gambling. Studies related to TP deficits and impulsivity disorders were retrieved from multiple literature databases, through predefined inclusion and exclusion criteria. From the 197 obtained documents, 47 were selected for analysis, and a final set of 15 studies was retrieved for this review. Regardless of some conflicting findings, the available results suggest that patients with orbitofrontal lesions produce and reproduce significantly less time and estimate time periods significantly longer than healthy subjects. Patients with borderline personality disorder show decreased time perception and patients with antisocial personality disorder seem to execute more premature responses during time estimation tasks. Stimulant dependent individuals also tend to overestimate the time intervals, and pathological gamblers demonstrate shorter time horizons than social gamblers. Taken together, the available data suggest that impulsive individuals tend to overestimate the passage of time and to execute more premature responses, producing and reproducing less time, but more research is necessary to increase the strength of the evidences on this issue. This systematic review updates evidences of distortions in TP in impulsivity, improving the understanding of the relations between these two variables.

Contents

This review aims to identify evidences of distortions in time perception (TP) in people with impulsivity disorders, or in other conditions where impulsivity traits are characteristically present, namely traumatic brain injuries, psychopathy and other personality disorders, addictive behavior disorders, and pathological gambling. This systematic review was informed by the Cochrane Collaboration guidelines (Alderson & Green, 2002; Higgins & Green, 2011).

TP is defined as an inherent ability of human beings and other organisms, necessary to relate impulsive behavior to the environment where it occurs, given that the environment includes stimuli such as lights, smells, sounds, and flavors to which all animals are sensitive (Castro, Carvalho, Kroger-Costa, & Machado, 2013).

Some empirical studies suggest an association between TP and impulsivity (Bauer, 2001; Wittmann et al., 2011). Impulsivity refers to a difficulty of self-control, which may be manifested in the daily routine

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in several ways, for instance: extraversion, impatience, inattention, neglect, engagement in risk situations, search for new experiences and sensations, depleted insight on injury (Hollander & Evers, 2001). This is a symptom in several psychiatric disorders deemed as impulse control disorders (e.g., pathological gambling, substance abuse), as well as in several personality disorders (e.g., borderline personality disorder – BPD, antisocial personality disorder – APD), and mood disorders (e.g., bipolar disorder) (APA, 2013), being also evident in neurological pathologies associated with behavioral disinhibition (Hollander & Evers, 2001).

As Correa, Trivino, Perez-Duenas, Acosta, and Lupianez (2010) explain, impulsivity can be related to a deficient temporal preparation of inhibitory processes. Understanding how impulsive individuals perceive time may shed light on important decision-making and behavior monitoring mechanisms, and this work is all the more important as impulse control difficulties are characterized by a predisposition to gratify immediate desires and impulses, including aggressive and violent ones, regardless of the consequences to one's self or to others. In fact, many studies relate impulsivity to violent and aggressive behavior (e.g., see Chen et al., 2014; Derefinko, DeWall, Metze, Walsh, & Lynam, 2011; Irwin & Gross, 1995; Volavka, 2014).

Regarding the consequences of altered time perception to decision-making processes in impulsive individuals, Wittmann and Paulus (2008) bespeak through a literature review the premise that these individuals have a more subjective experience of time, overestimating the duration of time intervals and, thus, discounting the value of delayed rewards more pronouncedly than people with better self-control. The thesis is that impulsive individuals usually choose smaller and immediate rewards, instead of delayed but larger rewards, possibly because subjects with marked impulsivity traits have an accelerated sense of time (Berlin, Rolls, & Iversen, 2005). A longer TP is associated with higher costs, leading to the selection of alternatives with more immediate results.

With this review we intended to make a further contribution to fill the gap in the existing literature concerning the distortions in TP in people with impulsivity traits.

We oriented this paper as a systematic summary on TP deficits in impulsivity disorders, reviewing their components, describing their results, and providing recommendations for future work.

1. Method

1.1. Search strategy

Studies were identified by searching multiple literature databases in EBSCOhost, including Academic Search Complete, Education Source, MEDLINE, PsycARTICLES, PsycBOOKS, SocINDEX with Full Text, and SPORTDiscus with Full Text. In order to avoid publication and source selection bias, these database searches were supplemented by additional hand searching. The key search terms were: Impulsivity disorders OR psychopath* OR sociopath* OR antisocial* – AB abstract; AND time perception OR temporal perception – Tx All Text; Not psychopatho* – AB abstract. The search was not constrained by any geographic, temporal, or linguistic factors.

As suggested by the Cochrane Collaboration, the selection of studies for eligibility and data extraction was undertaken by three independent reviewers in order to reduce the likelihood of missed studies or errors in classification (Alderson & Green, 2002; Higgins & Green, 2011). Any disagreements between reviewers were discussed and a consensus was reached.

Only empirical studies were included. Studies that did not have a control/comparison group were excluded from this review, except correlational-based studies in which continuous measures of impulsivity were used as predictors of time perception. Studies limited to children were also excluded.

A total of 197 studies, published between 1934 and 2014, were identified from all databases and search methods. After duplicate removal, the abstracts of 49 studies (17 from Academic Search Complete, three from Education Source, 14 from MEDLINE, 12 from PsycARTICLES, one from PsycBOOKS, one from SocINDEX, one from SPORTDiscus) were screened (see Fig. 1). From these, 29 studies were excluded because did not have a comparison group ($n = 12$) and/or comprised children only ($n = 17$). The remaining 20 studies were fully read and assessed for eligibility. Five studies were further excluded for not being related to the theme. Thus, a total of 15 studies were reviewed and their findings presented here.

2. Results

A summary of the characteristics of included studies is presented in Table 1. Across studies, the total number of participants was 1848 ($M = 264.0$, $SD = 513.0$, Min = 15; Max = 679), with 726 ($M = 103.7$, $SD = 190.2$, Min = 15; Max = 266) participating in the experimental groups and 1122 ($M = 160.3$, $SD = 326.3$, Min = 15; Max = 679) in the healthy comparison groups. The studies by Havik et al. (2012) and Schulreich, Pfabigan, Derntl, and Sailer (2013) had only one sample of healthy participants ($n = 58$ and $n = 21$, respectively) and their impulsivity measures were related to time perception.

The studies reviewed use a variety of methods to assess TP: time estimation tasks (6 studies); time reproduction tasks (4 studies); time production tasks (4 studies); and time discrimination tasks (2 studies). Information delivered in five of the studies does not allow accurately knowing the methods used.

In *time estimation tasks*, participants usually observe images separated by a variable time interval of some seconds (Min = 400 ms; Max = 90 s). The participants must indicate the time they believe to have elapsed between images.

In *time reproduction tasks*, participants also observe two images separated by a variable time interval (Min = 500 ms; Max = 14 s). After a few seconds, a new image appears and the participants must press a key when they believe the same amount of time has passed as in the previous time interval.

In *time production tasks*, the computer indicates to the participants a time interval to be produced (Min = 500 ms; Max = 90 s). Then, participants observe an image indicating the start of the time count and press a key when they believe to have reached the indicated time.

In *time discrimination tasks*, two consecutive time intervals are typically presented (varying from a minimum of 100 ms and a maximum of 1875 s) and participants judge if the second was shorter or longer than the first.

Two of the reviewed studies used sounds (Bauer, 2001; Wittmann, Leland, Churan, & Paulus, 2007), while five used images (Berlin et al., 2010; Havik et al., 2012; Mioni, Mattalia, & Stablum, 2013; Mioni, Stablum, McClintock, & Cantagallo, 2012; Schulreich et al., 2013). However, eight studies (Berlin & Rolls, 2004; Berlin et al., 2005; Hodgins & Engel, 2002; Klingemann, 2001; MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006; Petrovici & Scheider, 1994; Petry, Bickel, & Arnett, 1998; Smart, 1968) do not indicate such information, as most of them are focused on self-report measures of time perspective, instead of experimental tasks of TP.

2.1. Time perception and traumatic brain injuries (TBI)

Only four studies were focused on TP in patients with TBI. Research shows that patients with orbitofrontal lesions are significantly more impulsive than healthy comparison groups (e.g., Berlin et al., 2005), although little is known concerning the importance of the orbitofrontal cortex (OFC) for TP. Interestingly, the reviewed studies found that patients with orbitofrontal lesions produce and reproduce significantly shorter time periods

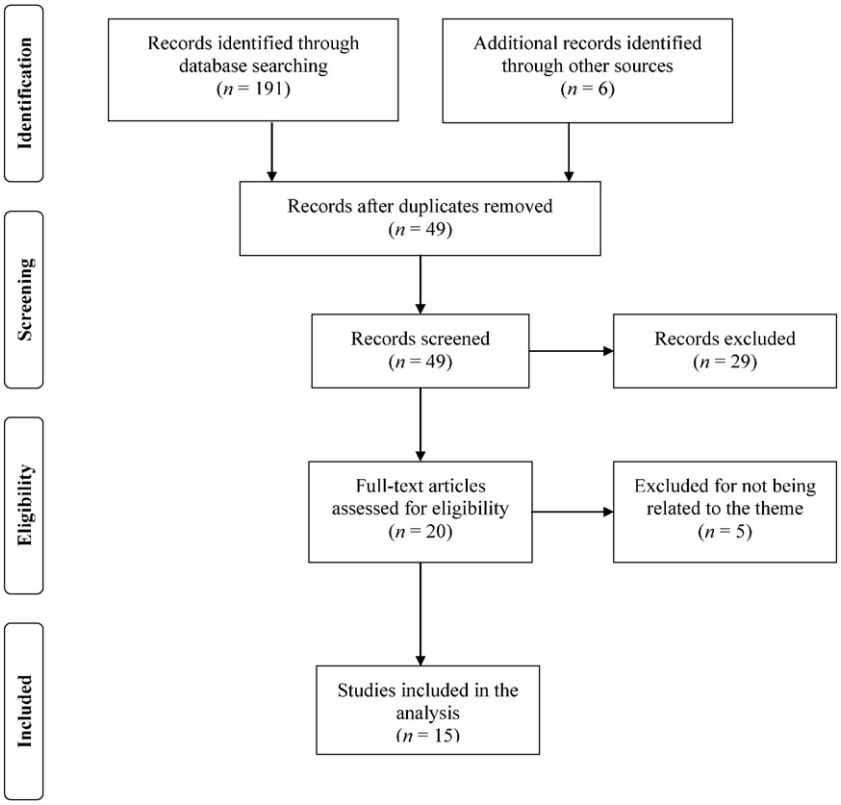

Fig. 1. Flow diagram of literature search.

and estimate these periods significantly longer than healthy subjects (Berlin et al., 2005; Mioni et al., 2012, 2013; Petrovici & Scheider, 1994).

Other brain areas were also found to be important concerning TP. Petrovici and Scheider (1994) analyzed patients with brain injuries looking for a relationship between lesions on the left or right hemisphere and changes of temporal perception. Individuals with brain injury were compared to general surgery patients on three TP methods: (a) production; (b) reproduction; and (c) time estimation. Brain injury patients reported a slowed down subjective impression of time passage. Moreover, in objective measures of TP, these patients displayed a trend to either underestimate or overestimate time intervals frequently exceeding its normal boundaries, particularly in the case of patients with right-sided parieto-occipital lesions (Petrovici & Scheider, 1994). Recently, Mioni et al. (2013) also compared patients with TBI with a healthy comparison group and found no significant differences in tasks of time production. However, differences were observed in reproduction and temporal discrimination tasks, given that these tasks involve increased demands of attention, working memory, and executive functions. Thus, the deficit in TP in patients with TBI may be related to those cognitive functions, instead of changes in the internal clock. On this matter, Mioni et al. (2012) studied the prospective memory (PM) in patients with TBI and the relationship between executive functions and TP. Patients and healthy participants completed a time-based PM task and a time reproduction task, as well as tasks of executive functions. TBI participants revealed more variability in the time reproduction task than healthy participants. However, no data is presented regarding the direction of the reported variability (underproduction vs. overproduction).

Summing-up, studies on TBI suggest that these patients tend to produce and reproduce shorter time periods and make longer estimations of these periods than healthy subjects, but there are some conflicting findings, perhaps due to different TP methods and the heterogeneity of the lesions.

2.2. Time perception in personality disorders

Patients with BPD seem to score similarly to patients with OFC lesions on impulsivity measures, and estimate that significantly more time had passed between events compared to people without BPD (Berlin et al., 2005), indicating a hasty subjective sense of time in these patients. Also, according to Berlin et al. (2010) individuals with borderline and schizotypal personality disorder (SPD) performed significantly worse on a delayed match to sample task when compared to healthy comparison groups, but had preserved function on TP. Berlin and Rolls (2004) have found that the BPD patients produced intervals close to the target time (10, 30, 60, 90 and 90 s) but significantly shorter than healthy participants. They also overestimated time intervals, suggesting an accelerated subjective sense of time, even if no statistical differences were found compared to people without BPD. One implication of these findings is that some of the core characteristics of BPD, in particular impulsivity, may be related to TP deficits (in terms of a decreased time production) and a faster subjective sense of time.

Concerning antisocial personality disorders, Schulreich et al. (2013), aiming to investigate the dual-process models of psychopathy, implemented an experimental paradigm in which participants had to estimate the course of one second, getting positive or negative feedback at the end, according to their performance. The self-centered impulsivity, as evaluated by Psychopathy Personality Inventory-Revised (PPI-R; Alpers & Eisenbarth, 2008; Lilienfeld & Andrews, 1996) was the only personality trait showing an effect over TP. Specifically, subjects with higher impulsivity scores overestimated time intervals, a result that is consistent with the findings of Havik et al. (2012). Thus, patients with personality disorders or, at least, showing higher

Table 1
Summary of studies characteristics.

Study Id	Measure(s) to assess TP	Methodological aspects		Main findings(s)
		Experimental group (n)	Comparison group (*n*)	
Berlin et al. (2005)	Time estimation and production tasks	Borderline personality disorder –BPD (19) Orbitofrontal lesions – OFC (23) Other prefrontal lesions – PFC (20)	Healthy – H (39)	- OFC and BPD patients produce significantly less time than H group. - OFC patients estimate that significantly more time had passed than individuals without OFC
Mioni et al. (2013)	Time reproduction, production, and discrimination tasks	Traumatic brain injury – TBI (15)	H (15)	- Higher temporal variability in TBI patients. - Temporal performance on the time reproduction task was associated with attention, working memory, and executive function, indicating the involvement of higher order cognitive functions in order to perform the time reproduction task. - There was minimal involvement of higher order cognitive functions on the time production task.
Mioni et al. (2012)	Time reproduction task	Severe TBI (18)	H (18)	- H individuals performed significantly better than TBI patients, as they were more accurate in their responses closer to the target.
Petrovici and Scheider (1994)	Time estimation, production, and reproduction tasks	Patients with brain lesions (80)	Surgery patients without brain damage – (107)	- Patients showed a tendency to under – or overestimation of time intervals, often exceeding the pre-established normal boundaries by far. - Vulnerability of the right hemisphere on the tasks for time judgment, especially in the case of right-sided parieto-occipital lesions.
Berlin et al. (2010)	Time perception task	BPD (16) Schizotypal personality disorder – SPD (17)	H (15)	- Individuals with BPD and SPD performed significantly worse on the delayed match to sample task when compared to H individuals, but had preserved time perception.
Berlin and Rolls (2004)	Time production task	Self-harming BPD inpatients (19)	H (39)	- BPD patients produced less time than H individuals. - The subjects with BPD had not time estimation differences from healthy comparison individuals in terms of total time estimated.
Schulreich et al. (2013)	Time estimation task	Correlational-based study comprising 21 healthy participants		- Subjects with higher impulsivity scores revealed longer estimated time intervals.
Havik et al. (2012)	Time estimation task	Correlational-based study comprising 58 healthy participants		- Healthy subjects with higher levels of impulsivity produced longer time intervals compared to low impulsivity subjects. - The subjective perception of time duration could be a suitable candidate for a general mechanism behind the stopping, the quick responding, and dysfunctional decisions in daily life. - The subjective time perception and stimulus after-effects deserve more attention as possible indicators of impulsivity.
Klingemann (2001)	–	Patients at both alcohol and drug clinics (266)	H (679)	- Patients at both alcohol and drug clinics have a lower degree of Future orientation and a higher Past Negative orientation than the general population. - The patients unexpectedly score lower on the Present Hedonistic time perspectives.
Petry et al. (1998)	–	Heroin addicts (34)	H (59)	- Heroin addicts were less likely to predict events far into their own future, less likely to envision extended futures for others, and less likely to organize the future. - Rewards may require an elaborate time perspective.
Smart (1968)	–	Alcoholics (33)	Social drinkers (33)	- Striking differences were found between the alcoholics and social drinkers in two aspects of future time perspective: alcoholics, where given unstructured tasks with no explicit mention of time, show far less expensive perspectives than do social drinkers.
Bauer (2001)	Time estimation task	Presence (20) vs. absence (37) of a comorbid diagnosis of Antisocial Personality Disorder – APD	Participants with no history of substance abuse and no diagnosis of APD (26)	- Cocaine-dependent patients with APD executed more premature responses during a time estimation task than cocaine-dependent patients who did not meet APD diagnostic criteria.
Wittmann et al. (2007)	Time discrimination, reproduction, and estimation tasks	Stimulant dependent individuals – SDI (15)	H (15)	- SDI have impairments in sensorimotor timing and that longer time intervals are overestimated due to more impulsivity.
Hodgins and Engel (2002)	–	Pathological gamblers (30)	Social gamblers (36)	- Results showed significantly shorter time horizons in pathological vs. social gamblers but few differences between pathological gamblers and psychiatric patients.
MacKillop et al. (2006)	–	Pathological gamblers (24) Potential pathological gamblers (40)	Non-pathological gamblers (41)	- No differences between pathological, potential pathological, and non-pathological gamblers were evident on either the Stanford Time Perspective Inventory (STPI) or objective Future Time Perspectives (FTP) measures of time perspective.@- Psychological distress may play a more significant role in distorted time perspective than addiction *per se*.

impulsivity traits, tend to overestimate the passage of time, like patients with orbitofrontal lesions do.

2.3. Time perception and addictive behavior disorders

Although not concerning time perception *per se*, research using the Zimbardo Time Perspective Inventory (ZTPI) demonstrated that patients who were admitted to treatment facilities for drug and alcohol problems (Klingemann, 2001) are more oriented to the present and less oriented to the future. Moreover, in research using Wallace's Test of Future Events it was shown that opioid-dependent people (Petry et al., 1998) and alcoholics (Smart, 1968) had a shorter length of future time perspective.

Bauer (2001) studied time estimation in former cocaine-addicted or cocaine and alcohol addicted patients, with or without APD, using also EEG measures. Participants were asked to press a key to estimate a range of 2 s following an X stimulus in the middle of the screen. If the responses were assigned within a 500 ms window of the targeted time, a 500 Hz tone was presented. When response-latencies exceeded this time window, a 2000 Hz tone was presented. The results showed that the groups of cocaine-addicted patients with comorbid APD were more premature in their temporal estimates.

Individuals addicted to stimulants, whom in other studies showed more pronounced discount functions and would have provided shorter time horizons, calculated time intervals of 53 s as substantially longer than participants without an addiction, implying a faster internal clock (Wittmann et al., 2007). The overestimated duration of long time intervals that was found in stimulant dependent individuals (SDI) was attributed to higher impulsivity. Therefore, for the first time it was shown an altered time processing in SDI, which can be explained by increased impulsivity and associated with higher discount of delayed gratifications.

To the best of our knowledge, there are no experimental studies on time perception concerning pathological gamblers. However, research on time perspective found significantly shorter time horizons in pathological vs. social gamblers, with few differences between the former and other psychiatric patients (Hodgins & Engel, 2002). Contrarily, MacKillop et al. (2006) report no differences between pathological, potentially pathological, and non-pathological gamblers on the Stanford Time Perspective Inventory (STPI) nor in Future Time Perspectives (FTP) measures. On the basis of these results, they hypothesize that psychological distress may have more effects in distorting time perspective than addiction itself (MacKillop et al., 2006).

3. Discussion

This literature review was intended to answer the following question: do people with impulsive traits show alterations in time perception, with confirmed tendencies to overestimate, under-produce, and under-reproduce time? As far as we can tell from the literature, this is the first systematic review to organize such evidences following the Cochrane Collaboration guidelines, including proper inclusion and exclusion criteria, and the use of three independent researchers for assessing eligibility.

As a first remark, the small number of studies attests to the fact that TP alterations in impulsivity disorders are understudied. Secondly, TP research on clinical populations typically characterized by marked impulsivity shows inconsistent results, despite a trend towards the expected direction.

Patients with TBI (Mioni et al., 2012, 2013), including patients with orbitofrontal lesions (Berlin et al., 2005; Minkwitz et al., 2012), and parietal lesions (Petrovici & Scheider, 1994), as well as individuals with APD (Bauer, 2001), BPD (Berlin & Rolls, 2004), substance use disorders (Klingemann, 2001; Petry et al., 1998; Smart, 1968; Wittmann et al., 2007), and also pathological gamblers (Hodgins & Engel, 2002; MacKillop et al., 2006) are known to be significantly more impulsive than healthy individuals.

Regarding TP, patients with TBI tend to perform worse than healthy individuals, with the last ones giving more accurate responses in reference to target time periods. Specifically, patients with orbitofrontal lesions tend to show a faster perception of time, as they overestimate time intervals and produce significantly less time than patients without orbitofrontal lesions (Berlin et al., 2005).

Patients with APD tend to execute more premature responses during time estimation tasks (Bauer, 2001), compared to people without APD. BPD patients also show time production deficits, in particular a faster subjective sense of time (decreased time production), also compared with people without BPD. Importantly, Berlin and Rolls (2004) theorize from their findings that impulsivity, one of the core characteristics of BPD, may be related to the above-mentioned TP deficits.

Stimulant dependent individuals also tend to overestimate the duration of relatively long time intervals, an effect that was attributable to higher impulsivity (Wittmann et al., 2007). Although focused on time perspective, other research on substance use disorders shows that heroin addicts are less likely to predict events far into their own future, less likely to envision extended futures for others, and less likely to systematically organize the future (Klingemann, 2001). Similar differences were found between alcoholics and social drinkers, with alcoholics showing far less expansive future time perspective than social drinkers do (Smart, 1968).

Likewise, pathological gamblers tend to demonstrate shorter time horizons than social gamblers, but the small differences between pathological gamblers and other psychiatric patients suggest that a shortened time horizon is not a unique feature of addicted populations (Hodgins & Engel, 2002).

Regardless of the findings synthesized above, some studies did not report TP alterations in the same type of groups or conditions. For example, according to Berlin et al. (2010) individuals with BPD seem to have preserved TP, which is inconsistent with evidences of time production deficits from other studies of BPD patients (e.g., Berlin & Rolls, 2004). Also, despite evidences of temporal distortions in addicted individuals (e.g., Hodgins & Engel, 2002), it is not clear if psychological distress plays a main role in this effect, instead of addiction *per se* (MacKillop et al., 2006).

This systematic review has some limitations. As in all systematic reviews, there is the risk of reporting bias. As only studies published in identifiable sources were included, unpublished studies may be more likely to not have significant results, thus indicating the absence of TP deficits in the groups or conditions that we have analyzed. For this reason, we had no constraints regarding geographic and linguistic criteria. Also, the adherence to the Cochrane Collaboration guidelines, including definition of accurate inclusion and exclusion criteria, the use of independent reviewers, as well as the efforts to diminish publication bias, strengthen this systematic review and better elucidate about TP deficits in impulsivity disorders.

Summing-up, the last 40 years have allowed to study time perception in impulsivity disorders. As a main conclusion, the whole existing data suggests that there are changes in TP associated with impulsivity. The existing literature suggests that impulsive individuals tend to overestimate the passage of time, execute more premature responses, and reproduce less time, but more research is necessary to bring increased consistency to these findings. Noteworthy, even if a number of studies report TP alterations in clinical conditions that have impulsivity as a core feature, very few studies were focused on the impulsivity *per se*. Thus, it would be useful to adopt the RDoC approach for further research developments regarding the effects of impulsivity on time perception, conceiving impulsivity as a phenotype, which shall be accurately evaluated in multiple levels – physiologic, neurophysiologic, and behavioral – through suitable tools.

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