



Review

The cognitive roles of behavioral variability: Idiosyncratic acts as the foundation of identity and as transitional, preparatory, and confirmatory phases



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ABSTRACT

Behavior in obsessive compulsive disorder (OCD), in habitual daily tasks, and in sport and cultural rituals is deconstructed into elemental acts and categorized into common acts, performed by all individuals completing a similar task, and idiosyncratic acts, not performed by all individuals. Never skipped, common acts establish the pragmatic part of motor tasks. Repetitive performance of a few common acts renders rituals a rigid form, whereby common acts may serve as memes for cultural transmission. While idiosyncratic acts are not pragmatically necessary for task completion, they fulfill important cognitive roles. They form a long preparatory phase in tasks that involve high stakes, and a long confirmatory phase in OCD rituals. Idiosyncratic acts also form transitional phases between motor tasks, and are involved in establishing identity and preserving the flexibility necessary for adapting to varying circumstances. Behavioral variability, as manifested in idiosyncrasy, thus does not seem to be a noise or by-product of motor activity, but an essential cognitive component that has been preserved in the evolution of behavioral patterns, similar to the genetic variability in biology.

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1. Prolog: The question of “How fixed are fixed action patterns”?

The study of instinctive behavior by Lorenz (1958) and Tinbergen (1951), the founders of ethology (and Laureates of a 1973 Nobel Prize), led to the description of rigid behavioral templates as **fixed action patterns** (Brigandt, 2005; Moltz, 1965), which are “stereotyped patterns of movement that may be species-characteristic; spatiotemporal sequences of muscle contractions that are relatively constant in form and that generally belong to a functional system” (Immelmann and Beer, 1989). Fixed action patterns were also described as an “innate, highly stereotyped response that is triggered by a well-defined simple stimulus; once the pattern is activated, the response is performed in its entirety” (Alcock, 1993). The notion of fixed action patterns stimulated the search for hard-wired simple and indivisible behaviors, each elicited by a specific stimulus and then run to completion. The intensive search for such behavioral templates gave rise to the question of “How fixed is a fixed action pattern?” (Brown, 1994; Gaioni and Evans, 1986; Pellis, 1985; Shleidt, 1974). This question was based on the understanding that even in a highly stereotyped form, there is also a certain variability. Accordingly, an alternative term was suggested: *modal action pattern* (Barlow, 1977), based on the recognition that behavioral patterns have a fixed but also a variable component (Berridge et al., 2005). Furthermore, it was suggested that variation and change are inherent and endogenous in routines (Becker, 2004; Keren et al., 2010). Nonetheless, in studying behavioral patterns the focus has been naturally on the invariant components that shape the regular form (Golani, 1981; Stahlman and Blaisdell, 2014) and create recognizable behavioral templates (“gestalts”) (Koenderink, 2014).

Routinized daily motor tasks are voluntary behaviors that can be explained by their purpose, intent, or goal. Once the goal is apparent, one can predict the content of a purposeful or goal-oriented behavior and distinguish the irrelevant or unnecessary acts that might be embedded in such behaviors, and this is especially true for habitual acts (Neuringer, 2014). In this context, behavioral variability and its possible adaptive value is the focus of the present article. Specifically, the questions posed in this survey regarding the variability in motor patterns are: first, what are the building blocks that constitute this variability; second, where and when does this variability occur in motor behavior; and third, what might be the underlying mechanisms and the adaptive value of the inclusion of a variable component in routinized motor tasks? In order to answer these questions, similar motor tasks were deconstructed into their elemental acts, with the rationale being that acts that vary in repeated performance of the same motor task are not pragmatically necessary for completion of that task, as explicit in the completion of that same task without these acts in some repetitions. The acts (elementary building blocks) that constitute variability are termed **idiosyncratic acts**, and their performance is examined first in motor rituals of human patients suffering from obsessive-compulsive disorder (OCD), where such acts are manifested in excess. Idiosyncratic activity is then studied in normal daily tasks, in sport rituals, in cultural rituals, and in stereotyped behavior.

2. Excessive manifestation of idiosyncratic acts: The case of OCD rituals

2.1. What is OCD and what characterizes OCD motor rituals?

In order to determine and scrutinize acts that are not required for a specific behavior, we sought to detect repetitive motor performance with an over-expression of acts that are seemingly unnecessary or irrelevant for the ongoing behavior. Such acts are conspicuous in the motor behavior of humans suffering from OCD.

This is a severe, chronic psychiatric problem, listed by the World Health Organization among the ten most debilitating illnesses in existence. *Obsessions* refer to recurring, persistent thoughts, impulses, or images that inappropriately intrude into awareness and cause marked distress or anxiety. *Compulsions* are the need to repeat physical behaviors such as checking, or mental behaviors such as counting things, and occur as a response to an obsession or in accordance with strictly applied rules (DSM-IV; APA, 2000). The most common form of OCD behavior is that of compulsive checking (Henderson and Pollard, 1988; Rasmussen and Eisen, 1992), which in some cases may continue to be performed for hours and in extreme cases may prevent the subject from sleeping or leaving home. Compulsive behavior of OCD patients is usually referred to as “rituals” or “ritualized behavior” (Boyer and Liénard, 2006; see also Eilam et al., 2012), which includes complex behavioral sequences that have no obvious goal and seem irrelevant to the ongoing behavior. For OCD patients, the urge to display complex activity in a particular order is disabling and impairing (Rapoport, 1989a,b, 1990), and patients who perform more rituals are typically more anxious and more bothered by their intrusive thoughts (Boyer and Liénard, 2006). That is, in the case of OCD, the more ordered the rituals and behavioral routines, the more severe is the mental disorder. There is great variability in the behavior of different patients: for example, one patient may check whether the house door is locked, another whether the stove is turned off, yet another whether the car is locked properly, while still another checks whether the amount of soap in the dishwasher is precisely as recommended, and so on. This variability has led to a major obstacle in studying OCD, in particular hindering quantitative analyses of compulsive behavior.

2.2. Idiosyncratic acts in OCD rituals

In a previous study it was suggested that repetition, addition, and reduced functionality are the hallmarks of OCD compulsions (Eilam et al., 2012). This was based on comparing rituals of OCD patients with the performance of non-OCD control individuals. Specifically, a control non-OCD person was matched according to gender, age, and education to a specific OCD patient, and was requested to perform on camera the same motor task that the OCD patient performed. By this comparison it was possible to divide the repertoire of their acts (repetitions excluded) into: (i) **common acts**, performed by both the patient and the control individual; and (ii) **idiosyncratic acts**, performed by only one of them (Fig. 1). Implicit in this classification was the notion that idiosyncratic acts are not necessary for task completion, as evident in the completion of the same task by the other person without performing these acts (Zor et al., 2009a,b).

Following this definition, it was found that a set of 43 OCD rituals comprised 15-fold more idiosyncratic acts than in the performance of respective non-OCD individuals (Fig. 2). Compulsions in these 43 OCD rituals (of 37 patients) also comprised two-fold more common acts than their respective non-OCD group, reflecting a repetition of acts that were performed by both the OCD and non-OCD individuals (Fig. 2). This indicates that while OCD is characterized by the repetition and addition of acts, the idiosyncratic component (addition) outweighs the repetition component. The conspicuous feature of compulsive behavior is thus the excess of idiosyncratic acts that seem neither necessary nor relevant to the ongoing behavior, thus leading to defining OCD behavior as pessimal (the antonym of optimal), featuring reduced functionality (Zor et al., 2009b). Moreover, this addition of numerous idiosyncratic acts in OCD behavior extended the duration of task performance compared to that of non-OCD individuals (207 ± 47 compared to 79 ± 21 s, respectively, for the 43 rituals; $t_{42} = 3.55$, $p < 0.001$), conveying to the observer the impression that the patient was

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