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Work process-related lead userness as an antecedent of innovative behavior and user innovation in organizations

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ABSTRACT

Recent studies have identified that employees can be lead users of their employing firm's products, and valuable sources of product innovation, residing within organizational boundaries. We extend this line of thought by recognizing that employees can be lead users with regard to internal work processes. We define work process-related lead userness (WPLU) as the extent to which employees experience unsatisfied process-related needs ahead of others, and expect high benefits from solutions to these needs. We hypothesize a positive association with user innovation in the workplace, evidenced by the development of tools, equipment, materials and methods. We test a moderated mediation model delineating how and when WPLU is related to user innovation within organizational boundaries. Drawing on survey data from 104 employees and 13 supervisors in a forensic services organization, we find that WPLU contributes to user innovation via engagement in innovative work behavior, especially when employees have higher self-efficacy (perceived capability to overcome obstacles) and lower job autonomy (situational constraints on the job).

1. Introduction

Lead users are ahead of the majority of users in a population with respect to an emerging trend, expecting high benefits from solutions to needs they encounter (von Hippel, 1986). Prior research mostly views lead users as customers outside the boundaries of the firm (Urban and von Hippel, 1988). These external lead users often innovate to serve their own needs, developing product innovations that are often judged to be commercially attractive (Franke and von Hippel, 2003). The revenue potential of new products based on lead user inputs exceeds that of classical product development projects (Lilien et al., 2002).

Recent studies showed that lead users are also present within organizations. In-house business units may be lead users (e.g., Chatterji and Fabrizio, 2012; Roy and Cohen, 2015; Block et al. 2016), as may be individual employees with regard to the products that the company sells (e.g., Schweisfurth and Raasch, 2015; Wadell et al., 2013). These 'embedded' lead users demonstrate favorable organizational behaviors (Schweisfurth and Raasch, 2015) and offer high-quality new product ideas (Schweisfurth, 2017).

In this study we extend the idea of lead userness within organizational boundaries. We recognize that employees, beyond products, can be a source of innovation in internal work processes. Consider Tim Berners-Lee, who at his time at CERN (Geneva) created the World Wide Web:

> *"Creating the web was really an act of desperation, because the situation without it was very difficult (…) [The web] was designed in order to make it possible to get at documentation and in order to be able to get people - students (…) for example - to be able to come in and link in their ideas, so that we wouldn't lose it all if we didn't debrief them before they left"* (Connecting all humanity, 2007).

Tim Berners-Lee had unsatisfied work-related needs as he was lacking a tool to gather and communicate information with remotely connected people. This unsatisfied need motivated made him to develop the World Wide Web. Another example is the heart-lung machine developed by Gibbon (1978), a physician pushing the boundaries of surgical operations. Likewise, the breathalyzer - device to measure blood alcohol content from breath samples – was invented by Robert Borkenstein, a police officer frustrated by the lack of methods to establish people's alcohol usage (Grauls, 2009). Typewrite correction

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fluid was first created by Betty Nesmith, a secretary at Texas Bank. She was among the first to use the electric typewriter, on which it was impossible to erase mistakes (Grauls, 2009). All these innovations emerged in the workplace and were driven by individuals experiencing limitations doing their jobs.

We define work process-related lead userness (WPLU) as the extent to which employees experience unsatisfied work process-related needs ahead of others, and expect high benefits from solutions to these needs.

The contribution of our study is threefold. First, we expand lead userness studies that have been concerned with employees as 'embedded' users of the products sold by the company (e.g., Schweisfurth and Raasch, 2015; Schweisfurth, 2017). Specifically we introduce WPLU as a construct capturing lead userness within organizational boundaries, concerned with internal work processes. We investigate its relationship with user innovations as an individual-level outcome variable. In the workplace user innovations are concerned with functionally novel applications (in tools, equipment, materials, methods) that individuals develop for personal use (von Hippel, 2005). Embedded lead userness studies did not consider innovation outcome variables, but focused on behavioral measures and idea characteristics (e.g., Schweisfurth and Raasch, 2015). In doing so we capture a phenomenon not yet discussed, but important to organizations. Note that a positive relationship between WPLU and user innovation is not self-evident, as employees facing unsatisfied work-related needs may not be able or willing to innovate. We therefore seek to understand the mechanism of how WPLU can be related with user innovation, and in what circumstances.

Our second contribution is that we identify innovative work behavior as a behavioral mechanism explaining why WPLU can be associated with user innovation at work. Innovative work behavior is "the intentional creation, introduction and application of new ideas within a work role, group or organization, in order to benefit role performance, the group, or the organization" (Janssen, 2000: p. 288) and includes both idea generation and idea implementation behaviors (Parker and Collins, 2010). Investigating innovative work behavior as a mediating constructs helps us to clarify that WPLU (as an individual characteristic) and user innovation (as an outcome variable) are not equivalent, but rather associated depending on employees' engagement in generating and implementing ideas.

Third, we explain under what circumstances WPLU triggers employees to innovate. Drawing on Bandura's (2001) self-efficacy theory, we expect that the behavioral mechanism (WPLU-innovative work behavior-user innovation) is more prominent when employees have higher self-efficacy and lower job autonomy. Specifically, at higher self-efficacy employees will be more likely to put effort and be persistent to solve unsatisfied work process-related needs; self-efficacy reflects perceived capability to overcome obstacles to achieve goals. Low job autonomy implies that employees face more situational constraints in their jobs, so that work-process related needs become more salient. Our approach deviates from the conventional focus of investigating main effects (see Anderson et al., 2014, for a review); we consider self-efficacy and job autonomy as moderators of the association between WPLU and innovative work behavior, and subsequent user innovation in the workplace.

The empirical context of our research is a forensic services organization that provides criminal justice organizations with evidence and analyses. Forensics is a work environment where job-related innovations often emerge from daily operations and, as such, is a suitable context for our investigation.

We find that WPLU is indeed related with user innovation in the workplace, and that this relationship is partially mediated by innovative work behavior, especially when employees have higher self-efficacy (perceived capability to overcome obstacles) and lower job autonomy (situational constraints on the job). Beyond contributing to the lead userness literature, our findings have implications for the broader individual innovation literature. Our study reveals a source of value creation not yet on the radar: bottom-up process innovation driven by shop-floor employees who seek to create personal use value at work. This deviates from individual innovation and employee proactivity perspectives which revolve around organization citizenship behaviors driven by intrinsic motivation, affect and perceived personal competences (Anderson et al., 2014; Parker et al., 2010). WPLU complements from the individual innovation antecedents (traits, contexts and roles) studied so far (Anderson et al., 2014).

2. Theory and hypotheses

The concept of lead userness is derived from so-called 'lead users' in innovation management research (von Hippel, 1986, 2005). Lead users are individuals who in a particular context perceive strong needs ahead of others, and expect high benefits from a solution to their needs. As such, lead users foreshadow needs that others will experience later.

The first generation of studies looked into external lead users; developing solutions to products of which commercial firms can take advantage. Urban and von Hippel (1988) showed that lead users are inclined to develop solutions to satisfy their own needs. These solutions are more likely to be broadly applicable as other, future users will benefit from adoption (Franke and von Hippel, 2003; Franke et al., 2006). Also, when external lead users are involved in the product development projects of incumbent firms, the revenue potential is superior to classical product development projects (Lilien et al., 2002). Lead users are also often found at the edge of new, emerging industries (Shah and Tripsas, 2007). For example, mountain bikes were originally developed by lead users who were experimenting with normal bikes in extreme conditions like steep descents and rough terrain. Lead users started modifying their regular bikes to better meet these conditions. In overview, early studies considered lead users as an extra-organizational source of product innovation, including representatives of existing or potential customer populations, and front-runners in analog fields of expertise (e.g., Urban and von Hippel, 1988; Lilien et al., 2002; Hienerth and Lettl, 2017).

Recently a second generation of lead userness studies emerged. Employees can be lead users with regard to the products that their company sells (e.g., lead users of mountaineering equipment employed by producer firms in the mountaineering equipment industry). Such 'embedded' lead users are argued to combine need-related information (in their role as users) and solution-related information (being employed by the producer company with engineering capabilities). Compared to regular employees, embedded lead users are more likely to be customer-oriented, internal boundary spanners, and engaging in innovation behaviors (Schweisfurth and Raasch, 2015). Product ideas of embedded lead users are considered to be of better quality compared to external users (Schweisfurth, 2017).

2.1. Work process-related lead userness and user innovation

We introduce work process-related lead userness (WPLU) as a third lead userness construct, recognizing that employees can have unsatisfied needs related to internal work processes rather than products. In the process of doing their jobs, employees may experience strong needs ahead of others regarding tools, equipment, materials or methods, and expect high benefits from solutions, as in the examples of the World Wide Web and heart-lung machine.

We hypothesize that employees high in WPLU will more likely develop user innovations in the workplace, concerned with new or improved tools, equipment, materials or methods, in order to solve unsatisfied process-related needs. In studies to date individual innovation by employees is considered as an organizational citizenship behavior driven by intrinsic motivation (Anderson et al., 2014). The related literature on proactive behavior also recognizes the importance of intrinsic motivation, together with employees' affectivity with their jobs and with their perceived personal competences (Parker et al., 2010;

Wu et al., 2013). Whether or not employees perceived a personal need to innovate is an aspect that has been neglected.

Our hypothesis is in line with the conceptual work by Farr and Ford (1990) who proposed that negative circumstances, i.e. employees' felt need for change, may trigger individual innovation. Few studies have followed up on this proposition, testing job dissatisfaction as a proxy for felt need for change. These studies found no (Yuan and Woodman, 2010) or only indirect evidence (Zhou and George, 2001). We suspect that job dissatisfaction is too broad to reflect personal need to innovate, as job dissatisfaction may have multiple causes (e.g., poor management practices, bureaucracy).

Our reasoning is that WPLU is a better match with the conceptual proposition offered by Farr and Ford (1990). Employees high in WPLU are first to face particular problems in their jobs, and expect high benefits from solutions to these problems - so they will be motivated to obtain a solution. Being ahead of others, their organization may be less inclined to invest in developing solutions to specific problems they face, and ditto for commercial, external producers.

The empirical pattern we expect to observe for WPLU resembles with external lead users. External lead users invent new products because they are ahead of an emerging trend and do not (yet) represent an attractively-sized market, while commercial firms are only interested when demand increases (Von Hippel, 1986). Corresponding first-generation studies reported strong and positive relationships between lead userness and developed/prototyped user innovations. For example, Urban and von Hippel (1988) investigated a sample of CAD software users and found that respondents who displayed lead user characteristics had likely developed their own CAD software (87%), while those low in lead userness had not (1%). Franke and Shah (2003) studied innovations by consumers in sports communities and found that kite surfers high in lead userness were more likely to have innovative ideas, and that the solutions to these ideas were more commercially attractive. We hypothesize:

H1: Work process-related lead userness (WPLU) is positively related with user innovation in the workplace.

2.2. Mediating role of innovative work behavior

We anticipate that innovative work behavior mediates the relationship between WPLU and user innovation. As WPLU is expected to heighten employees' felt need for change (Farr and Ford,1990), it will motivate these employees to engage in innovative work behavior with the intention to satisfy their work process-related needs.

As mentioned in the introduction, innovative work behavior includes both idea generation and idea implementation behaviors (Parker and Collins, 2010). With regard to idea generation we expect that employees with high WPLU are more likely to identify opportunities for change and improvement (Schweisfurth and Raasch, 2015). Such employees have rich knowledge about their unsatisfied needs ahead of others. They will be more open to new solutions as they stand to obtain high personal benefits (von Hippel, 1986; Morrison et al., 2004; Schreier and Prügl, 2008). Next, WPLU is expected to facilitate idea implementation. Given that lead users face strong incentives to obtain a solution, they will perceive lower risks and more value from engagement in innovation (Morrison et al., 2004). This motivates them to take initiative to reduce the gap between their current and desired state. Idea implementation behaviors such as prototyping and field-testing a solution will be more likely. In this vein recent studies of embedded lead userness have empirically related the concept with employees' innovative work behavior (Schweisfurth and Raasch, 2015). We expect the same positive association will be observed for WPLU.

Next, we expect that innovative work behavior is positively associated with user innovation. If employees engage in innovative work behavior with the intention to satisfy their work process-related needs, user innovations (in tools, equipment, materials, methods) is the expected outcome variable. Employees may have to generate and try out many ideas to solve their unsatisfied work-related needs. Those engaging in innovative work behavior are likely to achieve more user innovations due to their effort done. In line with this view, prior studies have indicated a positive (but not perfect) association between innovative work behavior and innovation output such as patents and technical reports (Zhou and Shalley, 2003) in an R&D context.

A positive relationship between innovative work behavior and user innovation may seem obvious, but we argue that it is not totally evident. While behavior captures innovative activities, user innovation refers to outcomes, such as new tools, equipment, materials or methods which are actually implemented. In general, outcomes of employees' behaviors are expected to be related with the behaviors themselves, but not perfectly as outcomes of organizational behaviors are more distal and also affected by other factors (e.g., strategy, industrial developments, organizational resources) (Campbell et al., 1990). Also, while innovative work behavior is intended to provide some kind of benefit (Jansen, 2000), these benefits are not restricted to work process-related needs. Alternative benefits from innovative behavior reasons are career development (Parker and Collins, 2010), manage one's image within the organization (Yuan and Woodman, 2010) and product/market development (Schweisfurth and Raasch, 2015). In sum, we have good reasons to differentiate innovative work behavior from user innovations, and hypothesize:

H2: Innovative work behavior mediates the relationship between WPLU and user innovation in the workplace.

2.3. Moderating roles of self-efficacy and job autonomy

To explore situational characteristics in which WPLU is more strongly related with innovation, we anticipate that employees' self-efficacy will be a positive moderator. Self-efficacy is an individual's belief in his or her capability to perform actions to achieve specific goals, and plays "a central role in the self-regulation of motivation through goal challenges and outcome expectations" (Bandura, 2001: p.10). Self-efficacy makes individuals opt for more challenging goals, expend more effort to achieve goals, persist in the face of obstacles, and perceive higher gains and fewer risks when being proactive.

We suggest that employees having higher self-efficacy are more likely to engage in innovative work behavior to fulfill unsatisfied work process-related needs. Previous studies have shown that employees high in self-efficacy are inclined to focus on goals based on their own needs, values, beliefs and interests (i.e., self-concordant goals) and regulate their behavior accordingly (Judge et al, 2005). Hence, those high in self-efficacy will focus more on their unsatisfied needs and rely on their first-hand need knowledge to come up with new ideas to fulfill those. Also, employees with high self-efficacy strive to master their environment (Bandura, 2001) so that they will more likely do effort to improve their situation in the face of deficiencies. In an empirical study, Bandura and Cervone (1983: p.1017) found that "the higher the self-dissatisfaction with a substandard performance and the stronger the perceived self-efficacy for goal attainment, the greater was the subsequent intensification of effort". In contrast, it is unlikely for employees with lower self-efficacy to fulfill their work process-related needs by innovating, because they are less confident to achieve goals and to challenge the status quo. We hypothesize:

H3: At higher levels of self-efficacy, the relationship between work process-related lead userness and innovative work behavior will be stronger, and vice versa.

We further suggest that the relationship between WPLU and innovative work behavior will be stronger when work-related needs are more salient. Following this notion, we focus on the situational characteristic of job autonomy, defined as the degrees of freedom,

independence and discretion in performing tasks (Morgeson and Humprey, 2006). Past studies showed that job autonomy and innovative behavior are directly and positively associated (Anderson et al., 2014), as job autonomy broadens individuals' perspectives and enables experimentation (e.g., Parker et al., 1997). Here, however, our focus is not on the direct effect of job autonomy, but on its role as moderator.

We expect that at high job autonomy work process-related needs become less salient and important, so that innovative work behaviour will be *less* likely. At high job autonomy, employees are allowed to adopt existing alternative approaches, to delay the problem by prioritizing other tasks, or to find extra resources to do the job less efficiently. Also, job autonomy provides opportunities to link new and existing knowledge and to acquire new information (Parker et al., 1997) and encourages employees to think actively (Wu et al., 2014), making first-hand need knowledge less critical to drive innovative behaviour. Finally, as highly autonomous employees have more control over their work, their desire to regain control when facing unsatisfied work-related needs will be less pronounced (e.g., Pittman and D'Agostino, 1989; Zhou et al., 2012).

In contrast, we have multiple reasons to expect that innovative behavior to satisfy work process-related needs is more likely at lower job autonomy. First, low job autonomy rules out alternative ways of how tasks can be done; low job autonomy comes with specific approaches to complete tasks, and with high goal clarity (Meyer et al., 2010; Roskes, 2015). Second, at low autonomy deficiencies in prespecified processes will be more salient, and prompt employees to generate new ideas based on their first-hand need knowledge (Parker et al., 1997). Third, when employees have less freedom to determine how to do their work, they are more likely to desire control and to engage in analytical thinking in order to find opportunities to control a negative environment (Zhou et al., 2012).

We remark that low job autonomy does not necessarily prevent employees to engage in innovative work behavior. It is quite common that employees sometimes deliberately hide innovation projects to 'prototype first, reveal later' and (partly) use their free time to innovate, a phenomenon known as bootlegging (Criscuolo et al, 2013). They may even engage in creative deviance, i.e. violate managerial/organizational instructions, to keep working on innovative ideas (Mainemelis, 2010). We hypothesize:

H4: At lower levels of job autonomy, the relationship between work process-related lead userness and innovative work behavior will be stronger, and vice versa.

2.4. Joint moderation of self-efficacy and job autonomy

Next, we anticipate a three-way moderation effect between WPLU, self-efficacy and job autonomy. Specifically, the association between WPLU and innovative behavior is expected to be stronger for employees with high self-efficacy and low job autonomy.

We expect that in low autonomy conditions employees' willingness to change will be reinforced especially for those high in self-efficacy. Our reasoning is similar to Speier and Frese (1997) who reported that self-efficacy is critical in motivating personal initiative at work at low levels of autonomy, rather than at higher levels. Two arguments apply. First, given that employees with higher levels of self-efficacy try harder to achieve goals important to them (Beattie et al., 2015), we expect that high-efficacy employees are even more motivated to innovate to satisfy work-process needs if their job autonomy is low - as the low-autonomy situation makes innovation more important to obtain a solution.

Second, high-efficacy employees are known to strive to change their environment when it provides them with limited opportunities to exercise control (e.g., in low autonomy situations) (Bandura, 2001). Having unsatisfied work process-related needs at lower levels of job autonomy will thus evoke employee behaviors to master the environment and overcome deficiencies at hand, especially for employees with high self-efficacy. In contrast, at high job autonomy satisfying work-related needs by innovating is less salient and important (as elaborated above) and will not spur high self-efficacy employees to expend effort.

Thus, building on Speier and Frese (1997) who found that employees take more personal initiative at high self-efficacy and low job autonomy, we hypothesize that:

H5: The moderating role of self-efficacy strengthening the relationship between work process-related lead userness and innovative work behavior will be enhanced at lower levels of job autonomy.

2.5. Integrated model

Based on the above reasoning we test a first-stage moderated mediation model to delineate how and when WPLU is related with user innovation in the workplace. Innovative work behavior is hypothesized to mediate the relationship as follows:

H6: The indirect effect from work process-related lead userness via innovative work behavior to user innovation is (a) stronger at high self-efficacy, (b) stronger at low job autonomy, and (c) even more enhanced in the simultaneous presence of high self-efficacy and low job autonomy.

Our hypotheses are shown in Fig. 1.

3. Data

We tested our hypotheses in a forensic services organization that provides criminal justice organizations with evidence and analyses. Forensics is a leading-edge environment where related innovations often emerge from daily operations. Cases present forensic workers with process-related needs that arise from the specifics of the situation, societal pressure to fight crime effectively, institutional pressures for

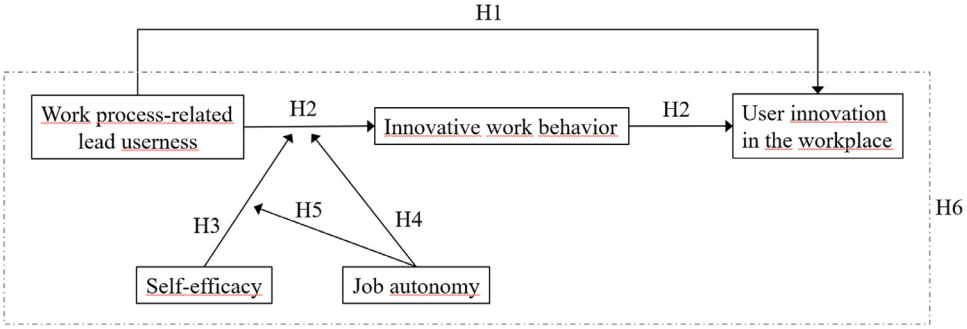

Fig. 1. Hypothesized relationships.

efficiency, and general technological advancements. This mix of factors implies that forensic workers regularly face situations in which standard tools, equipment, materials and methods can be improved: to simplify tasks, reduce mistakes, increase efficiency, or expand the scope of existing processes. We expected this setting to harbor a large proportion of advanced users of forensic equipment and techniques whose individual tasks may push them to innovate.

3.1. Participants and procedure

At the time of our research, the organization employed around 600 researchers, analysts and staff members. The organization provides forensic data and analyses to criminal justice organizations (e.g., the police, public prosecutors, judiciary and defense counsels) as well as national armies, intelligence agencies, counterterrorism organizations, and authorities concerned with wildlife conservation. Forensic researchers and analysts at the organization are usually technically educated. The organizational structure included three layers: top management (board of directors including department chairs), team leaders, and employees. We focused this study on employees in 13 teams concerned with services related to forensic DNA, firearms and ammunition, non-human biological traces and fingerprint identification.

Data were collected from three sources. First, we invited 118 employees of the teams involved in our research to complete a paper survey. We included multiple-item measures about WPLU, job autonomy and self-efficacy. Employees also answered questions about user innovations they had developed in the past three years. Reported user innovations were validated by the research team (see Section 3.2). One of the members of the research team personally distributed the questionnaires. One week later she personally reminded employees to take the survey. After two weeks, 106 employees had completed the survey (response rate 90%).

Second, we obtained full responses from thirteen supervisors (heading 13 work teams). They rated a list of innovative work behavior items for each team member (n = 118). Third, we obtained data from the organization's administration: age, gender, tenure (in years) and educational attainment.

Our merged sample included 104 employees from 13 work teams. The number of employees per team ranges from 4 to 14, with most teams having 7 to 9 members. The age of the responding employees ranged from 21 to 62 years with an average of 34 years. Sixty-six percent were female. Their tenure in forensic services ranged from 0 to 36 years with an average of 11 years. Thirty-four percent had obtained a master's or doctorate degree. Another 66 percent had a bachelor's degree.

3.2. Measures

Work process-related lead userness. Previous studies applied lead userness measures with two dimensions: 'high expected benefits' and 'being ahead of a trend'. We tailored Franke et al.'s (2006) measure to reflect lead userness with regard to work processes. The first dimension indicated to what extent employees experience unsatisfied work process-related needs. Three items from Franke et al. (2006) were modified to assure that respondents' mindset was with work processes, by starting with *When I think of the available tools, equipment, materials, methods and processes at work…"*. A sample item is *"…I am confronted with problems that cannot be solved by incumbent products on the market"*.

The second dimension, 'being ahead of a trend', reflected to what extent individuals are ahead of others in the particular context. It is usually measured with facet-specific items. For example, Franke et al. (2006) measured whether kite-surfers were ahead of their field by recording their airtime and mastery of freestyle techniques. As our focus on work processes implied a broad range of potential innovation objects, facet-specific items were not viable. Instead, we included two items: *"…I am usually ahead of other users in terms of desired new functionalities"* and *"…I have needs which others experience only later"*. (Similar measures were reported, e.g., by Faullant et al. (2012) and Schweisfurth (2017).) The response scale ranged from 1 (*never*) to 5 (*always*). Cronbach's α was .87 for the overall scale (.90 for the strong needs dimension, and .85 for the ahead-of-trend dimension).

Self-efficacy. We used Schwarzer and Jerusalem's (1995) generalized self-efficacy scale. Due to space restrictions, and as previous studies reported homogenous factor loadings, we randomly selected four items: *"Thanks to my resourcefulness, I know how to handle unforeseen situations", "If someone opposes me, I can find the means and ways to get what I want", "I can always manage to solve difficult problems if I try hard enough"* and *"I can usually handle whatever comes my way"*. The response scale ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). Cronbach's α was .73.

Job autonomy. We used Morgeson and Humphrey's (2006) three-item measure of work-methods autonomy, indicating freedom to choose methods used to perform tasks. This dimension most closely resembles with our theoretical argument that employees' inability to choose different work methods motivates them to innovate when faced with process-related needs ahead of others. A sample item is *"My job gives me considerable opportunity for independence and freedom in how I do the work"*. The response scale ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). Cronbach's α was .86.

Innovative work behavior. We asked supervisors to rate employees' innovative work behavior. We used three of the six items from Scott and Bruce's (1994) innovative behavior measure: "*This employee searches out new technologies, processes, techniques, and/or product ideas", "…generates creative ideas",* and *"…develops adequate plans and schedules for the implementation of new ideas"*. In Yuan and Woodman's (2010) study, these items had the highest factor loadings (> .70). The response scale ranged from 1 (*never*) to 5 (*always*). Cronbach's α was .90.

User innovation. We applied an extensive screening procedure to indicate the number of user innovations that employees had developed with regard to their work processes in the past three years. Based on the procedure developed by von Hippel et al. (2012) employees first self-reported any innovations developed for personal use at work: *"In the past three years, did you ever create […], or did you modify existing […], to be used at work?"*. To trigger respondents' recall, we posed this question four times, offering different cues: (a) tools or equipment, (b) materials or supplies, (c) methods or processes, and (d) any other. Next, we asked after each cue whether the forensic services institute could have bought an equivalent solution on the market. If yes, the claimed innovation was excluded for lack of functional novelty. We then cross-checked whether the innovation had been developed for personal use at work. If not, the claimed innovation was excluded. Finally, the respondent described with open-ended questions what s/he had created, why, and what was new about it. Two members of the research team examined and discussed these open-ended responses. Innovations lacking functional novelty were excluded. An example was "*I improved our lab's work processes by installing a denaturation block. I had it bought to improve the life expectancy of existing machines"* (claimed innovation in tools/equipment; applied an existing device with its intended purpose). An example of valid case was *"I improved a method of replicating bullets and sleeves. I have first been to Sweden to learn how they do it, then experimented to improve it and now apply it here. In the past we had to send the originals abroad for research or validation, but now we send copies of bullets/sleeves"* (innovation related to work methods/processes). To indicate user innovation, we counted the number of valid innovations for each respondent. The number of respondents with no, one, two, three or four validated innovations was 60, 34, 11, 1 and 0, respectively.

Control variables. We controlled for employees' tenure (in years), highest educational attainment (dummy for employees with a master's/PhD degree) and age (in years). These variables have been applied in previous innovative behavior studies (Janssen, 2000; Scott and Bruce, 1994) to proxy accumulated knowledge and innovation capabilities. We also included gender (dummy for females).

4. Findings

4.1. Measurement model

We specified WPLU as a second-order latent factor, indicated by two first-order latent factors (high expected benefits, being ahead of a trend), and both indicated by their corresponding items. Job autonomy, self-efficacy and supervisor-rated innovative behavior were specified as first-order factors indicated by three, four and three items, respectively. Factors were allowed to be correlated, but error terms of the items were not. The measurement model had a good fit (SB-χ^2 = 152.43, *df* = 96; CFI = .94; TLI = .92; RMSEA = .076; SRMR = .089) and was better than alternative models, including a model in which all items loaded on a single factor (SB-χ^2 = 645.25, *df* = 104; CFI = .40; TLI = .31; RMSEA = .227; SRMR = .186) and a two-factor model where all self-reported items loaded on a single factor and the supervisor-reported items loaded on the other factor (SB-χ^2 = 506.00, *df* = 103; CFI = .56; TLI = .48; RMSEA = .197; SRMR = .166). Moreover, supporting our approach to model WPLU as a second-order latent factor, our proposed measurement model was also better than a model treating WPLU as a first-order factor indicated by five items (SB-χ^2 = 248.59, *df* = 98; CFI = .83; TLI = .80; RMSEA = .123; SRMR = .112).

Table 1 presents descriptive statistics. We found that age was highly correlated with tenure. Accordingly, we did not include age as a control variable in our regression models. As we recruited participants from 13 work teams, our data had a nested structure (i.e., individuals nested within teams). ICC1 coefficients for all variables ranged from .10 (gender) to .38 (education), suggesting strong team-level variance of variables. This observation is reasonable given that all teams are from the same organization.

4.2. Testing hypotheses

We performed regression analysis while accounting for team-level variance. Specifically, we used a design-based modelling approach that "takes the multilevel data or dependency into account by adjusting for parameter estimate standard errors based on the sampling design" (Wu and Kwok, 2012: p.17). This analytical approach is appropriate for our research, as we are dealing with nonindependence while mechanisms at a single (individual) level are examined (Wu and Kwok, 2012). We performed the analysis in Mplus (TYPE = COMPLEX, ESTIMATOR = MLR) (Muthén and Muthén, 2012). In advance we mean-centered WPLU, self-efficacy and job autonomy to avoid multicollinearity among the independent variables and their interaction terms (Neter et al., 1996). Findings are shown in Table 2.

We first estimated a regression model of user innovation, including control variables, self-efficacy, job autonomy and WPLU (Model 1). We found that WPLU is positively associated with the number of validated user innovations (B = .29, p < .01). This is in line with H1.

Model 2 included innovative work behavior, which is positively related with user innovation (B =. 23, p < .05). This supports part of H2. The effect parameter of lead userness diminished, but was still significant (B =. 20, p < .05). Recognizing that user innovation is a count variable, we performed a robustness check by re-estimating Models 1 and 2 with Poisson regression. Results were identical, and available on request.

Model 3 is a regression analysis of innovative work behavior estimating the direct effect of WPLU. The model reveals that WPLU is significantly related, and again in line with H2 (B = .37, p < .01). To fully test H2 regarding the mediation effect, we used a nested-equation path analytic approach (Hayes, 2013) to estimate the indirect effect of WPLU on user innovation via innovative work behavior. We built a path model combining both Models 2 and 3, and estimated the indirect effect using Mplus (Muthén and Muthén, 2012) (output available on request). We found that innovative work behavior mediated the association between WPLU and user innovation (unstandardized indirect effect = .08, p < .01). H2 is supported. As WPLU remained significant in Model 2, innovative work behavior is a partial mediator. We elaborate on this finding in the discussion section.

In model 4 we added the interaction term between WPLU and self-efficacy. Its parameter is not significant (B = .02, *n.s.*), so H3 is rejected. Likewise, model 5 tests the interaction term between WPLU and job autonomy. Again, its parameter is not significant (B = -.09, *n.s.*). H4 is rejected as well.

Model 6 tests the three-way interaction between WPLU, self-efficacy and job autonomy. The interaction term is significant (B = -.23, p < .05) and improves overall fit compared to a model with only direct two-way interaction effects (Δ Pseudo-R^2 = .05). For further interpretation of the three-way interaction, Fig. 2 shows the simple slope regressions of innovative work behavior on WPLU at high and low levels of self-efficacy and job autonomy (at M + 1**SD* and M – 1**SD*, respectively).

At low job autonomy, WPLU was positively related to innovative work behavior when self-efficacy is high (unstandardized simple slope effect = 1.06, p < .01) and unrelated to innovative work behavior when self-efficacy is low (unstandardized simple slope effect = .20, *n.s.*). At high job autonomy, WPLU was positively related to innovative work behavior when self-efficacy is high (unstandardized simple slope effect = .32, p < .05), and unrelated to innovative work behavior when self-efficacy is low (unstandardized simple slope effects = .49, *n.s.*). We also compared the two slopes at high self-efficacy and found that the association between WPLU and innovative work behavior at low job autonomy was significantly stronger than the same association at high job autonomy (effect of difference = .74, p < .01). Altogether these findings suggest that the association between WPLU and innovative work behavior is stronger at higher self-efficacy especially when job autonomy is low. This finding supports H5.

To examine H6 regarding moderated mediation effects, we built a path model combining Models 2 and 6 and then estimated conditional indirect effects (available on request). In line with our findings for H3 and H4, we found no empirical support for H6a and H6b. With regard to H6c, we found that innovative work behavior mediated the association between WPLU and user innovation at high self-efficacy and low

Table 1
Descriptive statistics (n = 104).

		M	*Min*	*Max*	*SD*	ICC1	Correlations 1	2	3	4	5	6	7	8
1	Gender (female =1)	.66	.00	1.00	.48	.10								
2	Age (years)	34.07	21	62	7.59	.28	-.18							
3	Tenure (years)	10.95	0	36	7.33	.28	-.10	.85**						
4	Education (master's/PhD=1)	.34	.00	1.00	.48	.38	-.14	.14	-.01					
5	WPLU	2.51	1.00	4.00	.64	.12	-.11	.19	.11	.13				
6	Job autonomy	4.30	1.00	7.00	1.43	.31	-.24*	-.02	.00	.16	.05			
7	Self-efficacy	5.25	3.00	7.00	.78	.15	-.11	.09	.12	.11	.28**	.45**		
8	Innovative work behavior	3.02	1.00	4.67	.82	.18	-.07	-.04	-.13	.29**	.34**	.35**	.20*	
9	User innovation	.57	.00	3.00	.72	.14	-.09	.18	.11	.37**	.29**	.32**	.16	.46**

Notes: Two-tailed significance * p < .05, ** p < .01.

Table 2
Regression analyses based on a design-based modelling approach ($n = 104$).

Dependent variable:	User innovation				Innovative work behavior							
Independent variables:	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	S. E.	*B*	S. E.	*B*	S.E.	*B*	S. E.	*B*	S. E.	*B*	S. E.
Intercept	.35	.12	-.28	.12	2.81	.13	2.81	.13	2.79	.13	2.87	.11
Gender (female)	.08	.16	.06	.17	.10	.11	.10	.10	.13	.11	.08	.10
Tenure (years)	.01	.01	.01	.01	-.02	.01	-.02	.01	-.02	.01	-.02	.01
Education (master's/PhD =1)	.47**	.16	.39*	.17	.34*	.16	.34*	.16	.34*	.15	.32*	.14
Self-efficacy (SE)	-.08	.09	-.07	.08	-.05	.13	-.06	.13	-.04	.12	-.01	.11
Job autonomy (JA)	.15**	.04	.11**	.04	.18**	.07	.18**	.07	.18**	.07	.18*	.07
Work process-related lead userness (WPLU)	.29**	.06	.20*	.07	.37**	.08	.37**	.08	.41**	.09	.52**	.11
Innovative work behavior			.23**	.05								
WPLU × SE							.02	.15			.22	.17
WPLU × JA									-.09	.07	-.08	.10
SE × JA											-.12*	.06
WPLU × SE × JA											-.23*	.05
Model fit:												
-2 Log Likelihood	192.37		185.21		219.54		219.52		218.43		211.66	
Residual	.37		.35		.48		.48		.48		.45	
Δ Pseudo R^2			.05[a]				.00[b]		.00[b]		.05[c]	

Notes: Unstandardized effect parameters are shown. Two-tailed significance * $p < .05$ ** $p < .01$.
[a] compared to model 1.
[b] compared to model 3.
[c] compared to a model with all direct and two-way interaction terms, but not the three-way interaction term.

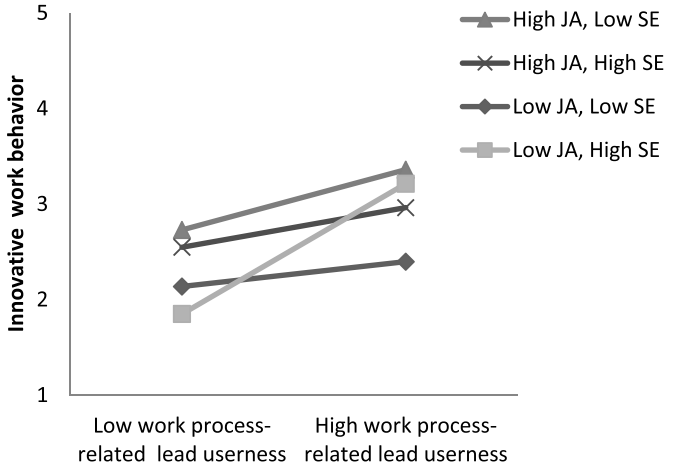

Fig. 2. Simple slopes of work process-related lead userness on innovative work behavior at levels of job autonomy and self-efficacy (n = 104). Notes: JA = job autonomy; SE = self-efficacy.

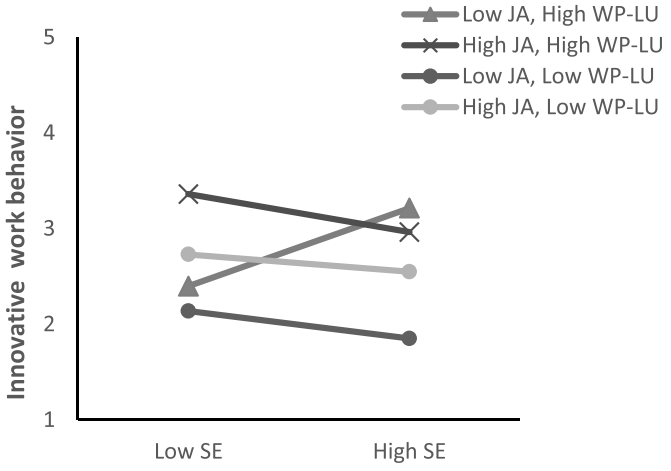

Fig. 3. Simple slopes of self-efficacy on innovative work behavior at levels of job autonomy and work process-related lead userness ($n = 104$) Notes: SE = self-efficacy; JA = job autonomy; WPLU = work process-related lead userness.

job autonomy (unstandardized indirect effect = .24, p < .01), and high self-efficacy and high job autonomy (unstandardized indirect effect = .07, p < .05) but not in other conditions (unstandardized indirect effect = .05, n.s., at low self-efficacy and low job autonomy; unstandardized indirect effect = .11, n.s., at low self-efficacy and high job autonomy). We also compared the two significant conditional indirect effects and found that the indirect effect at high self-efficacy and low job autonomy is stronger than the indirect effect at higher self-efficacy and higher job autonomy (differences in indirect effects = .17, $p < .01$). In conclusion we find support for H6c.

4.3. Supplementary analysis

To fully understand the three-way interaction effect we plotted the three-way interaction effect obtained in Model 6 to explore the simple slope effect of innovative work behavior on self-efficacy, at different levels of job autonomy and WPLU (see Fig. 3). This plot provides another way to test if our empirical observation is in line with our theorizing. We could expect that employees with high self-efficacy are more likely to innovate when they have unsatisfied needs ahead of others (i.e., higher WPLU) especially when they are constrained in how to do their jobs (i.e., lower job autonomy). Indeed, we found that self-efficacy is only positively related with innovative work behavior at low job autonomy and high WPLU ($B = .75$, $p < .05$) and not significant in other conditions. This finding supports our theorizing from a different angle.

5. Discussion

Our focus was on lead userness with regard to individual work processes. We investigated its role in driving innovations related to equipment, tools, materials or methods to facilitate employees' work processes. We proposed work process-related lead userness (WPLU) as the extent to which employees experience unsatisfied work process-related needs ahead of others, and expect high benefits from solutions to these needs. Drawing on a sample of forensic services workers, we observed that, under certain conditions, employees higher in WPLU produced more user innovations.

Work process-related lead userness expands the spectrum of

innovations associated with lead userness within organizational boundaries. Specifically, WPLU differs from embedded lead userness (Schweisfurth and Raasch, 2015), which focuses on employees seeking new or improved products that better fit their personal use-related needs, and/or wanting to assist the external user community to obtain better products which their organization sells. A first difference is that WPLU can bring benefits to different stakeholders. Embedded lead userness contributes to product innovation, and can help organizations to better serve external customers. Thus, embedded lead userness may help organizations to sustain and improve their market potential. In contrast, WPLU contributes to better work processes (tools, equipment, materials, methods) of which organizations' internal operations and other employees can take advantage. Second, WPLU is more broadly relevant within organizations. Embedded lead users are those who privately use their company's product, and both consumers and employees of the organization. By contrast, WPLU refers to employees in the work context only. This increases the number of organizations to which WPLU is relevant: basically all employees can be work process-related lead users while only some of them can be embedded lead users (i.e., in consumer product industries). This difference is important because how employees perceive themselves in relation to their organization may play a role in shaping their attention and in their potential contribution to innovation. Accordingly, we believe that it is valuable to distinguish WPLU as a construct different from embedded lead userness, and that future research exploring both types of lead userness is merited.

Our study reveals a source of value creation within organizations that has so far not been on the radar of individual innovation and proactivity studies: bottom-up process innovations driven by employees who seek to create personal use value at work. In the individual innovation literature, studies have so far mainly considered change-oriented organizational citizenship behaviors driven by intrinsic motivation (Anderson et al., 2014). Likewise, studies of employees' proactive behaviors have identified key antecedents related to perceived personal competences, intrinsic motivation, and affectivity with their jobs (Parker et al., 2010; Wu et al., 2013). Our findings in Table 2 show that WPLU is related with innovative behavior and user innovation, also when job autonomy (one of the strongest antecedents of individual innovation) is controlled for. This suggests that individual innovation can also emerge from employees' felt need for change. Despite that Farr and Ford (1990) were early to propose felt need for change, empirical evidence for its role in individual innovation emergence has been lacking. Few studies operationalized felt need for change with job dissatisfaction, but no (Yuan and Woodman, 2010) or only indirect (Zhou and George, 2001) correlations with individual innovation measures. We suspect that job dissatisfaction is too broad to capture felt need for change, as dissatisfaction may "arise for a variety of reasons, such as comparisons with competitors, environmental changes, personality traits (e.g., neuroticism), and the discovery of potential improvement opportunities" (Yuan and Woodman, 2010: p.329). Our findings suggest that WPLU is a more appropriate indicator for felt need for change. While job dissatisfaction resulting from dispositional traits, such as pessimism, may not be related with individual innovation, the extent to which individuals have work-related needs ahead of others seems to provide them with direction to formulate innovative goals and an internal reason to engage in innovative behavior. Accordingly, WPLU complements the individual innovation and proactivity antecedents studied so far (Anderson et al., 2014; Parker et al., 2010).

Our study identifies innovative work behavior as a behavioral mechanism underlying the relationship between WPLU and user innovation. Although seemingly obvious, this should not be taken for granted because not all employees with unsatisfied job-related needs will devote themselves to generating and implementing ideas. As we reported in Table 1, the correlation between WPLU and innovative work behavior (r = .34) and user innovation (r = .29) is small to moderate, similar to the correlation between embedded lead userness and innovative work behavior (r = .33) reported by Schweisfurth and Raasch (2015). This size of this correlation is reasonable if we take the organizational context into account. Individual innovation and proactivity studies have indicated that many employees refrain from these behaviors due to required personal investments (time, effort) and lack of recognition (Wu, 2019). In other words, there are costs that employees will evaluate before devoting effort to innovation, which explains why the correlation between WPLU and innovative work behavior and user innovation is small to moderate.

While identifying innovative work behavior as a behavioral mechanism, we found that its mediating role was only partial. A significant relationship between WPLU and user innovation remained (see Table 2, model 2). This suggests interesting directions for future research: which other factors can explain the relationship between WPLU and user innovation? We suspect that employees high in WPLU may find alternative ways to improve their situation. They may engage in social behaviors like networking and influencing others to have a solution developed for them (e.g., report their dissatisfaction to their manager, and influence him/her to prioritize solution finding, for example by hiring outsiders to develop a solution). Although lead users are by definition ahead of others in experiencing a need, past studies provide initial evidence for this 'innovation outsourcing' proposition. For example, Schweisfurth and Raasch (2015) found that embedded lead users are better boundary spanners. External product-related lead userness has also been related to opinion leadership (Morrison et al., 2000; Schreier et al., 2007) suggesting that lead users may be effective in delegating innovation activities to others. Alternative mediating variables merit investigation to fully uncover why WPLU is related to user innovation as an outcome variable.

Our third contribution is that we shed initial light on circumstances in which WPLU is related with innovative work behavior and user innovation. We found that employees with higher WPLU engage in innovative work behavior when they have higher self-efficacy, i.e. sense of capability for goal achievement, especially when they have less freedom to decide how to do their tasks - a situation that strengthens their felt need for change. WPLU was not related with innovative work behavior if employees had weak self-efficacy, regardless of their level of job autonomy. These findings support our contention that the link from WPLU to user innovations via innovative work behavior is not that obvious. Employees may well not be willing to and/or capable to take actions to fulfill unsatisfied job-related needs.

The three-way interaction effect we detected also has implications for the broader individual innovation and proactivity literature. First, we found empirical evidence reinforcing the role of self-efficacy especially in unfavorable situations (e.g., at low job autonomy). Although this function of self-efficacy has been widely suggested, only a few studies have provided evidence (e.g., Speier and Frese, 1997). Our study suggests that higher self-efficacy is critical for employees to innovate in order to address job-related needs, but only at lower levels of job autonomy. From a different angle, our supplementary analysis uncovered that self-efficacy is positively related to innovative work behavior at low job autonomy but high WPLU, but not in other conditions. This finding is in line with Speier and Frese (1997) who showed that higher self-efficacy helps to promote personal initiative only at lower levels of job autonomy – i.e. a compensating role of self-efficacy and job autonomy. Our finding suggest that this compensation happens in the presence of a strong reason to innovate (i.e. high WPLU).

Next, the interaction effect sheds new light on the role of job autonomy in facilitating individual innovation. We replicated the common insight that job autonomy is directly and positively associated with innovative work behavior. On top of this, our findings imply that (lack of) autonomy can be a restrictive situational characteristic. Lower job autonomy strengthens the positive association between WPLU and innovative work behavior, albeit for those high in self-efficacy. Thus, our study suggests a more hybrid role of job autonomy in shaping individual innovation. The classical view is that lack of job autonomy is a

contextual constraint which limits employees' opportunities to innovate (cf. Anderson et al., 2014). However, our study indicates that in such a context, employees may also be more likely to innovate in order to alleviate their situation, provided that they have strong reasons (high WPLU) and the perceived capability (high self-efficacy) to do so.

5.1. Implications for practitioners

Implications for managers are multifold. First, managers seeking to improve the functionality or efficiency of their work processes (tools, equipment, materials, methods) are offered guidance on where to look for potential improvements. Such improvements may already have been developed in-house by employees with lead user characteristics related to the technology in question. Employees experiencing a work process-related problem early on, and who are also likely to benefit substantially from a solution, may well have been triggered to prototype a solution already, or at least be good prospects for initiating one. High self-efficacy will be an additional clue to watch out for when trying to identify (potential or actual) workplace user innovators.

Organizations may want to facilitate user innovations arising from WPLU, in order to enhance process innovation. As user innovations based on WPLU emerge from employees' felt need for change, organizations may want to tailor their support structures to identify and to (help) develop these innovations early on. This can be done by including WPLU as a criterion in suggestions systems and innovation project management portfolios, or when programming process-related R&D. Extra weight can be given to innovations fulfilling strong process-related needs, especially when they can be considered ahead of an emerging trend.

Furthermore, our finding that low job autonomy can evoke individual innovation in some circumstances has interesting practical implications. Beyond being a constraint with direct negative implications for innovative behavior, lack of autonomy can apparently also spur innovative activities. Practically, as jobs across industries have different levels of job autonomy and it is not always possible to increase autonomy via job redesign, our findings suggest that low job autonomy is not harmful if workers face strong work-related needs, provided that workers are high in self-efficacy. This indicates that for low-autonomy jobs, recruitment procedures may be an alternative intervention for enhancing individual innovation at work.

5.2. Limitations and future research

Our study is not free from limitations, and these create opportunities for future research beyond the issues we already discussed.

Since forensic services is a leading-edge, innovative work environment marked by standardization of work methods imposed by legal requirements (forensic evidence is, after all, used to identify and imprison criminals), it provided a good setting to test our hypotheses. However, our empirical context is a specific one, which raises the question of generalizability. We anticipate that our findings will generalize to process-intensive work contexts especially when workers operate in dynamic environments, also because our sample had a nested structure in which individual employees operated in work teams - a common organizational structure. Nevertheless, validating and expanding our findings with new samples is encouraged. We especially recommend investigating whether WPLU is relevant in organizations where R&D for process innovation is systematically managed. In this context employees with high WPLU may report their problems to their internal R&D department, but alternatively, they may have good reasons to avoid doing and still innovate themselves (employees may fear disapproval, bureaucracy, prefer a solution perfectly tailored to themselves, or just enjoy innovating themselves).

Next, our independent variables were all measured at the same time using self-reporting methods. We believe that common method bias did not threaten our conclusions as innovative work behavior was supervisor-rated, and user innovation was measured with factual questions and an elaborate screening procedure. Also, our independent variables proved to be distinct in a confirmatory factor analysis, and detecting significant interaction effects is unlikely in the presence of common method bias (Siemsen et al., 2010). Despite this, our cross-sectional research design prevented us from taking a dynamic perspective with regard to our key variables. Self-efficacy and job autonomy may be related interactively (we thank an anonymous reviewer for pointing this out). For example, employees with higher self-efficacy may end up in high-autonomy jobs (Judge et al., 2000) which may spur their self-efficacy (Parker, 1998), and the correlation we observed between job autonomy and self-efficacy ($r = .45$) may reflect this. (In a follow-up analysis we used mean scores of self-efficacy and job autonomy to classify employees into four quadrants, and found that those employees were well distributed with 20% of the employees in the high self-efficacy and low job autonomy quadrant. This makes it unlikely that our interaction effect is driven by a small number of cases.) Nevertheless, for future research it would be informative to focus on longitudinal data of employees to fully depict how user innovation unfolds over time in the dynamics of their work situation (i.e., job autonomy), personal attributes (i.e., self-efficacy) and behavior (i.e., innovative work behavior).

A final issue is that it is uncertain to what extent WPLU-driven user innovations become visible to the organization. In user innovation research a general observed pattern is that individuals refrain from diffusing their innovations. After satisfying their personal needs they may not reveal due to lacking incentives (de Jong et al., 2015; 2018; von Hippel et al., 2017). Within organizations employees may feel deprived to diffuse user innovations too, especially in low autonomy conditions. Although we did not observe this in our forensic services organization (process standardization and legal requirements force employees to reveal their innovations as some point during the innovation process, in order to be useful as court evidence), lack of diffusion may be a concern in other organizations. Future research could investigate if WPLU-driven innovations reach their full potential by becoming broadly available to other employees.

5.3. Conclusion

We introduced WPLU as the extent to which employees experience unsatisfied process-related needs ahead of others, and expect high benefits from solutions to these needs. We found evidence that WPLU is related with user innovation in the workplace. The relationship is partially mediated by employees' innovative work behavior, especially when employees have higher self-efficacy and lower job autonomy. Future studies are encouraged to extend our work to investigate the function of WPLU in driving work-process innovations within organizations, especially in different organizational settings.

CRediT authorship contribution statement

Chia-huei Wu: Data curation, Formal analysis, Writing - original draft. **Jeroen P.J. de Jong:** Data curation, Formal analysis, Writing - original draft. **Christina Raasch:** Writing - original draft. **Sabrine Poldervaart:** Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Anderson, N., Potocnik, K., Zhou, J., 2014. Innovation and creativity in organizations: a state-of-the-science review, prospective commentary, and guiding framework. J.

Manag. 40, 1297–1333.
Bandura, A., Cervone, D., 1983. Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. J. Pers. Soc. Psychol. 45, 1017–1028.
Bandura, A., 2001. Social cognitive theory: an agentic perspective. Annu. Rev. Psychol. 52, 1–26.
Beattie, S., Hardy, L., Woodman, T., 2015. A longitudinal examination of the interactive effects of goal importance and self-efficacy upon multiple life goal progress. Can. J. Behav. Sci. 47, 201–206.
Block, J.H., Henkel, J., Schweisfurth, T.G., Stiegler, A., 2016. Commercializing user innovations by vertical diversification: the user-manufacturer innovator. Res. Policy 45 (1), 244–259.
Campbell, J.P., McHenry, J.J., Wise, L.L., 1990. Modeling job performance in a population of jobs. Pers. Psychol. 43 (2), 313–575.
Chatterji, A.K., Fabrizio, K., 2012. How do product users influence corporate invention. Organ. Sci. 23 (4), 971–987.
Connecting all humanity, 2007. Interview with Sir Timothy Berners-Lee, Father of the World Wide Web. June 22, 2007. Retrieved July 15, 2018, from http://www.achievement.org/autodoc/page/ber1int-1.
Criscuolo, P., Salter, A., Ter Wal, A.L., 2013. Going underground: bootlegging and individual innovative performance. Organ. Sci. 25 (5), 1287–1305.
de Jong, J.P.J., von Hippel, E., Gault, F., Kuusisto, J., Raasch, C., 2015. Market failure in the diffusion of consumer-developed innovations: patterns in Finland. Res. Policy 44 (10), 1856–1865.
de Jong, J.P.J., Gillert, N.L., Stock, R.M., 2018. First adoption of consumer innovations: Exploring market failure and alleviating factors. Res. Policy 47 (2), 487–497.
Farr, J.L., Ford, C.M., 1990. Individual innovation. In: West, M.A., Farr, J.L. (Eds.), Innovation and Creativity at Work: Psychological and Organizational Strategies. John Wiley and Sons, Oxford, UK, pp. 63–80.
Faullant, R., Schwarz, E.J., Krajger, I., Breitenecker, R.J., 2012. Towards a comprehensive understanding of lead userness: the search for individual creativity. Creat. Innov. Manag. 21 (1), 76–92.
Franke, N., Shah, S., 2003. How communities support innovative activities: an exploration of assistance and sharing among end-users. Res. Policy 32 (1), 157–178.
Franke, N., von Hippel, E., 2003. Satisfying heterogeneous user needs via innovation toolkits: the case of apache security software. Res. Policy 32 (7), 1199–1215.
Franke, N., von Hippel, E., Schreier, M., 2006. Finding commercially attractive user innovations: a test of lead user theory. J. Prod. Innov. Manag. 23, 301–315.
Gibbon, J.H., 1978. The development of the heart-lung apparatus. Am. J. Surg. 135 (5), 608–619.
Grauls, M., 2009. Gewoon geniaal! Hoe 100 uitvinders open schitterend idee kwamen Simply genious! How 100 inventors discovered their magnificent idea.
Hayes, A.F., 2013. Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. Guilford Press, New York.
Hienerth, C., Lettl, C., 2017. Perspective: understanding the nature and measurement of the lead user construct. J. Prod. Innov. Manag. 34 (1), 3–12.
Janssen, O., 2000. Job demands, perceptions of effort-reward fairness and innovative work behaviour. J. Occup. Organ. Psychol. 73, 287–302.
Judge, T.A., Bono, J.E., Locke, E.A., 2000. Personality and job satisfaction: the mediating role of job characteristics. J. Appl. Psychol. 85, 237–249.
Judge, T.A., Bono, J.E., Erez, A., Locke, E.A., 2005. Core self-evaluations and job and life satisfaction: The role of self-concordance and goal attainment. J. Appl. Psychol. 90, 257–268.
Lilien, G.L., Morrison, P.D., Searls, K., Sonnack, M., von Hippel, E., 2002. Performance assessment of the lead user idea-generation process for new product development. Manag. Sci. 48 (8), 1042–1059.
Mainemelis, C., 2010. Stealing fire: Creative deviance in the evolution of new ideas. Acad. Manag. Rev. 35 (4), 558–578.
Meyer, R.D., Dalal, R.S., Hermida, R., 2010. A review and synthesis of situational strength in the organizational sciences. J. Manag. 36, 121–140.
Morgeson, F.P., Humphrey, S.E., 2006. The work design questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work. J. Appl. Psychol. 91, 1321–1339.
Morrison, P.D., Roberts, J.H., Midgley, D.F., 2004. The nature of lead users and measurement of leading edge status. Res. Policy 33 (2), 351–362.
Morrison, P.D., Roberts, J.H., von Hippel, E., 2000. Determinants of user innovation and innovation sharing in a local market. Manag. Sci. 46 (12), 1513–1527.
Muthén, L.K., Muthén, B.O., 2012. Mplus User's Guide. Los Angeles, CA: Muthén & Muthén.
Neter, J., Kutner, M.H., Nachtsheim, C.J., Wasserman, W., 1996. Applied Linear Statistical Models, 4 ed. McGraw-Hill/Irwin, New York.
Parker, S.K., 1998. Enhancing role breadth self-efficacy: the roles of job enrichment and other organizational interventions. J. Appl. Psychol. 83 (6), 835–852.
Parker, S.K., Collins, C.G., 2010. Taking stock: Integrating and differentiating multiple proactive behaviors. J. Manag. 36, 633–662.
Parker, S.K., Bindl, U.K., Strauss, K., 2010. Making things happen: a model of proactive motivation. J. Manag. 36, 827–856.
Parker, S.K., Wall, T.D., Jackson, P.R., 1997. "That's not my job": Developing flexible employee work orientations. Acad. Manag. J. 40, 899–929.
Pittman, T.S., D'Agostino, P.R., 1989. Motivation and cognition: Control deprivation and the nature of subsequent information processing. J. Exp. Soc. Psychol. 25, 465–480.
Roskes, M., 2015. Constraints that help or hinder creative performance: a motivational approach. Creat. Innov. Manag. 24, 197–206.
Roy, R., Cohen, S.K., 2015. Disruption in the US machine tool industry: the role of inhouse users and pre-disruption component experience in firm response. Res. Policy 44 (8), 1555–1565.
Schreier, M., Prügl, R., 2008. Extending lead-user theory: antecedents and consequences of consumers' lead userness. J. Prod. Innov. Manag. 25 (4), 331–346.
Schreier, M., Oberhauser, S., Prügl, R., 2007. Lead users and the adoption and diffusion of new products: insights from two extreme sports communities. Mark. Lett. 18 (1-2), 15–30.
Schwarzer, R., Jerusalem, M., 1995. Generalized self-efficacy scale. In: Weinman, J., Wright, S., Johnston, M. (Eds.), Measures in Health Psychology: A User's Portfolio. Causal and Control Beliefs. NFER-NELSON, Windsor, UK, pp. 35–37.
Schweisfurth, T.G., 2017. Comparing internal and external lead users as sources of innovation. Res. Policy 46, 238–248.
Schweisfurth, T.G., Raasch, C., 2015. Embedded lead users—The benefits of employing users for corporate innovation. Res. Policy 44, 168–180.
Scott, S.G., Bruce, R.A., 1994. Determinants of innovative behavior: A path model of individual innovation in the workplace. Acad. Manag. J. 37 (3), 580–607.
Shah, S.K., Tripsas, M., 2007. The accidental entrepreneur: the emergent and collective process of user entrepreneurship. Strateg. Entrepreneurship J. 1 (1-2), 123–140.
Siemsen, E., Roth, A., Oliveira, P., 2010. Common method bias in regression models with linear, quadratic, and interaction effects. Organ. Res. Methods 13, 456–476.
Speier, C., Frese, M., 1997. Generalized self-efficacy as a mediator and moderator between control and complexity at work and personal initiative: a longitudinal field study in East Germany. Hum. Perform. 10 (2), 171–192.
Urban, G.L., von Hippel, E., 1988. Lead user analyses for the development of new industrial products. Manag. Sci. 34 (5), 569–582.
von Hippel, E., 1986. Lead users: a source of novel product concepts. Manag. Sci. 32 (7), 791–805.
von Hippel, E., 2005. Democratizing Innovation. MIT Press, Cambridge, MA.
von Hippel, E., de Jong, J.P.J., Flowers, S., 2012. Comparing business and household sector innovation in consumer products: Findings from a representative study in the United Kingdom. Manag. Sci. 58 (9), 1669–1681.
von Hippel, E., DeMonaco, H., de Jong, J.P.J., 2017. Market failure in the diffusion of clinician-developed innovations: the case of off-label drug discoveries. Sci. Public Policy 44 (1), 121–131.
Wadell, C., Sandström, G.Ö., Björk, J., Magnusson, M., 2013. Exploring the incorporation of users in an innovating business unit. Int. J. Technol. Manag. 61 (3–4), 293–308.
Wu, C.H., 2019. Employee Proactivity in Organizations: An Attachment Perspective. Bristol University Press, Bristol, UK.
Wu, C.-H., Parker, S.K., Bindl, U.K., 2013. Who is proactive and why? Unpacking individual differences in employee proactivity. In: Bakker, A.B. (Ed.), Advances in Positive Organizational Psychology. Emerald Group Publishing, Bingley, UK, pp. 261–280.
Wu, C.H., Parker, S.K., de Jong, J.P.J., 2014. Need for cognition as an antecedent of individual innovation behavior. J. Manag. 40, 1511–1534.
Wu, J.Y., Kwok, O.M., 2012. Using SEM to analyze complex survey data: A comparison between design-based single-level and model-based multilevel approaches. Struct. Equ. Model. A Multidiscip. J. 19, 16–35.
Yuan, F., Woodman, R.W., 2010. Innovative behavior in the workplace: The role of performance and image outcome expectations. Acad. Manag. J. 53, 323–342.
Zhou, J., Shalley, C.E., 2003. Research on employee creativity: a critical review and directions for future research. In: Martocchio, J.J., Ferris, G.R. (Eds.), Research in Personnel and Human Resource Management. JAI, Greenwich, CT, pp. 165–217.
Zhou, J., George, J.M., 2001. When job dissatisfaction leads to creativity: encouraging the expression of voice. Acad. Manag. J. 44, 682–696.
Zhou, X., He, L., Yang, Q., Lao, J., Baumeister, R.F., 2012. Control deprivation and styles of thinking. J. Pers. Soc. Psychol. 102, 460–478.