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The relationship between telework and job characteristics: A latent change score analysis during the COVID-19 pandemic

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Abstract

During the COVID-19 pandemic, a sizable proportion of employees conducted home-based telework to contain virus spreading. This situation made it possible to investigate the relationship between telework and job characteristics. Many positive and negative associations between telework and job characteristics have been proposed in the literature, but most studies relied on cross-sectional data as well as narrow samples (e.g. employees voluntarily choosing to telework). Repeated measures designs investigating the association between telework intensity and job characteristics using less selective samples are currently rare. To address this research gap, we collected data at two time points in Germany during the COVID-19 pandemic ($n = 479$) and investigated if change in telework intensity was associated with change in 19 job characteristics using structural equation modeling. Our analyses showed that—in contrast to several prior cross-sectional studies— telework intensity had a small to moderate association with only two out of the 19 job characteristics: Work scheduling and decision-making autonomy. Hence, the study challenges the previously assumed manifold positive and negative associations between telework intensity

and job characteristics and adds to the debate about the role of telework intensity as an antecedent of work design. Future studies should investigate the generalizability of the findings to non-pandemic work contexts.

KEYWORDS

job characteristics, job design, remote work, repeated measures, telecommuting, telework

INTRODUCTION

In light of increasing digitalization of business processes, telework has become widespread (Allen et al., 2015; Greer & Payne, 2014). In an effort to understand the advantages and challenges that employees experience while working remotely, theoretical and empirical studies sought to identify the job characteristics associated with telework (e.g. Greer & Payne, 2014; Sardeshmukh et al., 2012; Wang et al., 2021). Specifically, telework has been hypothesized to be linked to task (e.g. autonomy, Gajendran & Harrison, 2007), knowledge (e.g. required problem-solving competencies, Topi, 2004), and social characteristics (e.g. support, Sardeshmukh et al., 2012) of the job. Work design characteristics are considered as "key antecedent[s] of most of the major dependent variables we focus on in the field of psychology and management" (Parker et al., 2017, p. 412), highlighting the importance to investigate the telework–job characteristics linkage.

Although research has been conducted on work characteristics that come with telework as well as on the demands and challenges of telework, two shortcomings of past approaches must be noted: First, a crucial and seemingly unavoidable shortcoming of research on the demands imposed on individuals by specific work settings is that it is difficult to investigate using experimental designs (for exceptions using student samples, see for example Robert et al., 2009). However, typical correlational approaches may be prone to endogeneity (Antonakis et al., 2010), such that existing work contexts—in which telework is the predominant way of working—may have only been created for jobs that are particularly suited for this type of work. Moreover, these jobs may have been staffed with individuals who already possess the relevant competencies to succeed and are thus not particularly aware of some of the crucial work characteristics and related demands. Likewise, specifically those employees who possess the relevant skills may have crafted their jobs toward being more digital. Individuals may have self-selected into telework arrangements due to the larger freedom to conduct telework pre-pandemic (see also Wang et al., 2021, for similar arguments). Hence, past studies sampling from those jobs and individuals are likely to have provided an incomplete if not biased picture on inherent job demands.

As a second methodological problem, Allen et al. (2015, p. 61; see also Gajendran & Harrison, 2007) noted that "the majority of existing telework research, particularly as it pertains to workplace issues, is based on cross-sectional research designs." Past studies often used causal language implying that telework *impacts* or has an *effect* on job characteristics. For instance, when meta-analyzing past—mostly cross-sectional—studies on telework, Gajendran and Harrison (2007) discussed "the positive and negative *consequences* [emphasis added] of telecommuting" (p. 1524). Likewise, Sardeshmukh et al. (2012) proposed that "telework *introduces alterations* [emphasis added] in the job resources experienced by individuals in the form of autonomy, feedback and social support as a result of distance from the office" (p. 197).

In an effort to alleviate these two shortcomings of previous research, we made two important design choices for the study at hand. First, we gathered a sample of employees during the COVID-19 pandemic. As a result of nation-wide efforts to contain virus spreading (World Health Organization, 2020), a broad range of jobs and the respective employees moved abruptly from primarily working face-to-face to frequent telework (e.g. Hans-Böckler-Stiftung, 2020). Arguably, the COVID-19 pandemic has created a less selective sample of remote workers, thus resembling a natural experiment. Second, we chose a repeated measures design in which we tested whether change in telework intensity is associated with change in perceived job characteristics. Although our two time point repeated measures design cannot provide proof of causality and has its own limitations (e.g. the inability to study curvilinear change; Ployhart & MacKenzie, 2014), the within-person perspective adds important information to the cross-sectional literature on telework in that it allows examination of interindividual differences in intraindividual change in job characteristics and telework as well as *correlated change* between telework intensity and job characteristics (see Geiser et al., 2010, for an example study on correlated change). In other words, using this design one can investigate if change in telework intensity is associated with changes in the perception of job characteristics as reported by the same individuals over time.

Thus, this study makes several important contributions. First, it adds to current debates in the work design literature by examining how change in telework intensity is associated with change in work characteristics (see also Oldham & Fried, 2016). If telework indeed influences work design, we would expect that change in telework intensity is associated with change in work characteristics—over time and with less selective samples. Second, this study provides a holistic approach compared to prior studies that focused on a limited set of work characteristics. Note that the study draws on the Work Design Questionnaire by Morgeson and Humphrey (2006), which is based on a broad framework of work characteristics. Third and relatedly, this study not only provides a broad but also differentiated view on telework–work design associations, thus deepening our understanding of the advantages and challenges that employees experience while changing their telework intensity. From a practical perspective, the findings have the potential to inform and advance work design and also to help identify individual characteristics that contribute to successful telework. This, in turn, may serve as a starting point for future research on training programs or recruiting strategies.

STUDY BACKGROUND AND HYPOTHESES

Telework is defined as an arrangement "in which employees perform their regular work at a site other than the ordinary workplace, supported by technological connections" (Fitzer, 1997, p. 65). Telework can be performed from a variety of locations such as a satellite office or the employee's home, or a mixture of locations (Garrett & Danziger, 2007). One of the most prevalent forms of telework is home-based telework, especially at the time of the COVID-19 pandemic (European Foundation for the Improvement of Living and Working Conditions (Eurofound), 2020). Telework must be differentiated from other forms of remote work such as virtual teamwork. Virtual teamwork, in contrast to telework, is defined by Townsend et al. (1998) as a form of collaboration between "geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task" (p. 18). A common denominator of these concepts is that collaboration is primarily accomplished through information and communication technologies. Since the current study was conducted on the individual level and reflecting the fact that organizational measures to react to COVID-19 did

not necessarily involve creating virtual teams, but rather had employees work from home and at any time, we consider the term telework most appropriate for the context of our study.

Telework has been found to be positively related to important organizational criteria such as productivity and commitment (Martin & MacDonnell, 2012). Moreover, several positive associations were found on the individual level, including associations with employees' job satisfaction and role stress (e.g. Gajendran & Harrison, 2007). Furthermore, no differences regarding work-life balance were found for individuals working from home as compared to those working at the employer's office (Morganson et al., 2010). On the other hand, prior research has stressed a number of challenges associated with telework, such as reduced face-to-face contact (Greer & Payne, 2014) or reduced career development opportunities (e.g. Maruyama & Tietze, 2012).

Theories and empirical findings regarding the relationship between telework and job characteristics

The current study primarily adopts a work design perspective. The telework–job characteristics linkage can be investigated from multiple angles. In their review, Wang et al. (2021) identified three main research perspectives on the interplay between telework and work characteristics. First, work characteristics were examined as a moderator of telework-outcome relationships, thus identifying when and why telework is effective. Second, work characteristics were conceptualized as a consequence of telework, thereby informing scholars and practitioners about the way telework influenced other aspects of a job. Third, work characteristics were viewed as antecedent variables in the context of remote working, which helped to understand the context in which telework occurred. In line with Parker et al.'s (2017) call for more studies focusing on the *potential* antecedents of job design, the current study follows the second approach, whereby telework is conceptualized as a predictor variable of work characteristics (see also Gajendran et al., 2015; Gajendran & Harrison, 2007; Sardeshmukh et al., 2012; ter Hoeven & van Zoonen, 2015).

A widely recognized framework of work characteristics was introduced by Morgeson and Humphrey (2006). These authors identified crucial work characteristics defined by the tasks (e.g. autonomy), social aspects (e.g. feedback from others), knowledge requirements (e.g. job complexity), and contextual aspects (e.g. work conditions). The current study builds on this framework, not only because this framework is widely accepted but also because previous research has brought forward theorizing and some empirical evidence on how telework relates to these work characteristics. Furthermore, this broad framework allows us to identify and understand differential correlation patterns in a more holistic way than has been done before. Hypotheses were preregistered at AsPredicted (see preregistration document). However, we want to acknowledge that we made several revisions regarding the preregistration plan, making our research more exploratory than originally intended. All changes that we made are summarized in an accompanying file on the Open Science Framework (https://osf.io/ayg6n/). Along with the changes, we highlight the reasons for departing from the preregistration. In sum, we considered 19 job characteristics based on the framework of Morgeson and Humphrey (2006). In the next sections, we delineate hypotheses for 10[1] out of the 19 job characteristics (we investigated the relationships between telework intensity and the remaining nine job characteristics in an exploratory manner).

Note that while we primarily adopt a work design perspective, we also acknowledge that other theoretical perspectives exist and have been adopted in previous research. That is, the work characteristic of perceived social support via digital media may be explained by Social Presence Theory (Short et al., 1976), Media Richness Theory (Daft & Lengel, 1986), Electronic Propinquity

Theory (Korzenny, 1978), and Channel Expansion Theory (Carlson & Zmud, 1999), but also by Boundary Theory (Greer & Payne, 2014). Likewise, knowledge requirements may be theoretically derived from assumptions inherent in Media Synchronicity Theory (Dennis et al., 2008) and Information and Communication Technology Succession Theory (Stephens, 2007). As we are not aware of an overarching theoretical framework that has been developed to make predictions about the relationship of telework with all the WDQ dimensions, we review individual past empirical findings and different theoretical approaches that were adopted in the work design literature to derive our hypotheses for each WDQ dimension.

Telework and task characteristics

Allen et al. (2003) presented a theoretical framework of telecommuting effects and proposed that telecommuting influences self-regulation processes in the form of autonomy and personal control. Researchers frequently emphasized the reduced supervision and resulting flexibility in scheduling of work while working from home (Shamir & Salomon, 1985). Teleworkers may more easily take control over their work rhythms and task completion (Gajendran & Harrison, 2007), thus increasing perceptions of autonomy. Empirically, meta-analytical evidence provided by Gajendran and Harrison (2007) shows that teleworking is indeed positively related to perceptions of autonomy (see also Allen et al., 2015). Rather than adopting a dichotomous view on telework, more recent research suggests that taking a continuous view on telework is even more insightful (Allen et al., 2015). For instance, Gajendran et al. (2015) found that telework *intensity* was positively associated with perceptions of autonomy. Note that counter-perspectives have also been offered, speculating that non-optional telework may even come with perceptions of lower autonomy (Shamir & Salomon, 1985)—an argument that might increase in relevance during the COVID-19 pandemic. However, the vast majority of telework studies expected a positive association with autonomy (Gajendran & Harrison, 2007).

In addition to autonomy, telework may relate to feedback as a task characteristic. Feedback from one's job is defined as "feedback directly from the job itself or knowledge of one's own work activities" (Morgeson & Humphrey, 2006, p. 1323). Feedback from one's job needs to be differentiated from feedback from others (see also next paragraph) that focuses on "the degree to which others *in the organization* [emphasis added] provide information about performance" (Morgeson & Humphrey, 2006, p. 1324). Thus, the main difference lies in the source of feedback (people such as colleagues from the organization versus feedback directly from the job). Empirically, both feedback dimensions are strongly correlated but do also have unique components (manifest correlation of .42 in Morgeson & Humphrey, 2006; manifest correlation of .58 in Stegmann et al., 2010; $r = .56$ [T1] and $r = .52$ [T2] in our study), calling for both feedback dimensions to be treated separately. Telework may relate negatively to feedback from the job. As an example, teachers at school and lecturers at universities may have received less direct job feedback, because of distance teaching during the pandemic. In a qualitative study by Mukhtar et al. (2020), conducted during the pandemic in two university colleges, the interviewees reported that "due to lack of immediate feedback, teachers were unable to assess students' understanding during online lecturing" (p. 30). Taking a repeated measures perspective, we would expect that

H1: *Change in telework intensity is positively related to change in autonomy.*[2]
H2: *Change in telework intensity is negatively related to change in feedback from the job.*

We define change as the latent difference between time point 2 (T2) and time point 1 (T1) values and expect that a growth in telework intensity will be associated with a growth in autonomy perceptions; and that a decline in telework intensity will be associated with a decline in autonomy perceptions (H1). Regarding H2, growth in telework intensity should be associated with a decline in perceptions of feedback from the job; and decline in telework intensity should be associated with a growth in perceptions of feedback from the job.

Telework and social characteristics

As pointed out by Gajendran and Harrison (2007), most telework studies relied on *Social Presence Theory* (Short et al., 1976) and *Media Richness Theory* (Daft & Lengel, 1986) to derive hypotheses about the association between telework and social characteristics. These cues-filtered-out theories (Culnan & Markus, 1987; Walther, 2011) suggest that interaction quality suffers when workers extensively rely on media that lack the nonverbal cues inherent in face-to-face communication. Frequent face-to-face interaction may ease interpersonal bonding and psychological closeness of teleworkers (Gajendran & Harrison, 2007). However, and in contrast to this position, several other theories on computer-mediated interaction call for a more nuanced view on the effects of media use by considering the media skills and media experience of the interaction partners (e.g. as formulated in *Electronic Propinquity Theory*, Korzenny, 1978; *Channel Expansion Theory*, Carlson & Zmud, 1999). Greer and Payne (2014) made use of Boundary Theory to argue that remote work establishes physical and temporal boundaries between co-workers. Not being able to communicate with others at the office space and differing working hours may hinder informal communication and networking.

Empirically, while Becker et al. (2022) did not find the extent of telework to be associated with social support, several studies found a negative association with social support (Sardeshmukh et al., 2012; Vander Elst et al., 2017). Feelings of social and professional isolation have been argued to be challenging in remote work settings (Charalampous et al., 2019; Cooper & Kurland, 2002; Morganson et al., 2010). These findings coincide with a meta-analysis of Gajendran and Harrison (2007), who found that high telework intensity was associated with lower quality of co-worker relationships. In a similar vein, Moens et al. (2021) asked Flemish workers to report about their experiences with and fears about teleworking during the COVID-19 pandemic. From the 2673 respondents, 57.5% indicated that they thought telework has negative influences on their work-related relationships (colleagues). Allen et al. (2003, p. 139) proposed that "telecommuting frequency, telecommuting from locations not associated with the organization (home or neighborhood locations), … should be negatively related to perceptions of supervisor and co-worker support". Based on prior findings and taking a repeated measures perspective, we would thus expect that

H3: *Change in telework intensity is negatively related to change in social support.*
H4: *Change in telework intensity is negatively related to change in feedback from others.*

In other words, we expect that a growth in telework intensity will be associated with a decline in perceptions of feedback from others as well as of social support; and that a decline in telework intensity will be associated with a growth in perceptions of feedback from others as well as of social support.

Telework and knowledge requirements

Concerning knowledge characteristics, Topi (2004) hypothesized that locational proximity of co-workers may ease complex decision-making and that telework may require higher abilities (especially technical) to solve problems due to the distance to organizational support structures. In their recent COVID-19 experience survey, Moens et al. (2021) noted that around 17% of the individuals reported difficulties in dealing with the variety of media for communication. Indeed, researchers have proposed digital communication skill sets (e.g. Schulze et al., 2017; Spitzberg, 2006) and formulated theories about optimal task-technology fit (*Media Synchronicity Theory*, Dennis et al., 2008; *Information and Communication Technology Succession Theory*, Stephens, 2007)—specialized knowledge that may gain in importance while teleworking. Recently, Chong et al. (2020) applied conservation of resources theory (Hobfoll, 1989) to work under the COVID-19 pandemic. These authors argued that the new work situation along with constantly changing instructions from their supervisors may consume resources as it makes goal attainment more difficult and requires frequent adjustment. Specifically, they posited that tasks may become more complex and less routine and thus individuals will experience more task setbacks and, as a consequence, be more exhausted at the end of the day. Hence, their theoretical approach emphasizes cognitive requirements and emotional resources. In line with their assumptions, Chong et al. found that day-level task setbacks predicted daily emotional exhaustion. O'Neill et al. (2009) found lower average job complexity for home-based teleworkers compared to non-teleworkers, arguing that complex jobs might be less suitable for remote work, thus leading individuals with lower complexity jobs to telework. As the COVID-19 situation has reduced the voluntary character of teleworking, this argument might bear less fruit in the current study. From a repeated measures perspective, we would expect that

H5: *Change in telework intensity is positively related to knowledge characteristics (job complexity, information processing, problem solving, specialization).*

So, we expect that a growth in telework intensity will be associated with a growth in perceptions of knowledge requirements in the form of job complexity, information processing, problem solving, and specialization; and that decline in telework intensity will be associated with a decline in the aforementioned perceptions.

Personality variables

To investigate the stability of the findings regarding the telework intensity – job characteristics linkage, we included the Big Five personality characteristics (De Raad, 2000) as additional control variables in our latent variable models. Personality characteristics have been related to telework (e.g. attitudes toward telework, Clark et al., 2012; Gainey & Clenney, 2006) as well as to job characteristics (e.g. workload, Holman & Hughes, 2021). Several studies investigated how personality characteristics contribute to job crafting (i.e. job characteristics change; Bipp & Demerouti, 2015; Rudolph et al., 2017). For instance, Rudolph et al. (2017) meta-analytically investigated how individual differences relate to job crafting behavior. They found several meaningful associations between the Big Five and increasing job resources (e.g. increase in social job resources as a correlate of extraversion) as well as decreasing hindering job demands (e.g. neuroticism was

positively related to hindering job demand decrease) (see Tims et al., 2012, for definitions of job crafting dimensions). To rule out that the findings are due to workers´ personality, the Big Five were considered as controls in later analyses steps.

METHOD

The dataset for the study and an analysis script to reproduce the results can be accessed from the Open Science Framework (https://osf.io/ayg6n/?view_only=12420e25672941329097bc5a20e-c6e4e).[3] An excel file with the manifest scale correlations based on pairwise complete observations is available from the same repository.

Sample characteristics

An online-panel provider invited participants to respond to the survey at two time points. The first measurement time point was during lockdown (April 2020) in Germany. The second measurement time point took place in a less restricted (but not "normal" pre-pandemic) time period in October 2020 in Germany (e.g. restrictions such as mask-wearing in public transportation were still in place). As pointed out in the preregistration, the initial dataset was sequentially reduced to individuals, who (1) provided complete data for both time points ($n = 755$) and (2) did not already work from home "almost always" or even "always" before the pandemic ($n = 693$). Some additional criteria for data exclusion were specified that were not preregistered but that were necessary to make valid conclusions. Specifically, we only included individuals who (3) indicated being employed at both time points ($n = 659$ after exclusion), (4) indicated being able to work at both time points ($n = 561$ after exclusion), and (5) indicated no change in their employer from T1 to T2 ($n = 530$ after exclusion). Finally, a duration variable recorded the number of seconds that an individual needed to complete the questionnaire (survey time index). We set an average duration of 2 s per survey item as a cut-off criterion (e.g. Bowling et al., 2016; $n = 507$ after exclusion of cases).[4] Based on this reduced sample and in accordance with the preregistration, we (7) flagged outliers with z-scores of < -3 or >3 (Osborne & Overbay, 2004) on any WDQ dimension (at both time points) and subtracted these cases from the total sample. The final sample size after this step was $n = 479$ cases. The sample including individuals flagged as outliers were saved in a separate dataset for sensitivity analyses ($n = 507$). Detailed results regarding the sensitivity analyses can be obtained from the supporting information.

 The average birth year of the panel participants was 1970 ($SD = 9.85$). Sex of the participants was balanced with 52% women and 48% men. Most individuals reported holding a university degree (~40%), followed by a General Certificate of Education *Ordinary Level* (~29%; Mittlerer Schulabschluss in Germany) and a General Certificate of Education *Advanced Level* (~21%; Allgemeine Hochschulreife in Germany). An additional ~7% of participants reported having completed 9 years of school education and ~4% indicated holding a doctorate.

Measurement instruments

With few exceptions (detailed below), the measurement instruments followed the preregistration plan. To test the hypotheses, two kinds of variables needed to be collected: Job characteristics and

telework indicators. Additionally, personality variables based on archival data were considered as control variables in later analyses steps.

Job characteristics were assessed with the Work Design Questionnaire (WDQ, Morgeson & Humphrey, 2006; German version by Stegmann et al., 2010) using a 5-point rating scale (1 = *strongly disagree* to 5 = *strongly agree*). In total, 19 of the 21 dimensions of the WDQ were assessed at each time point: We included three facets of autonomy from the WDQ (work scheduling, decision-making, and work methods autonomy) to test H1. We measured the feedback from job scale to test H2. The social support items were used to test H3 and the feedback from others scale to test H4. Finally, the job complexity, information processing, problem solving, and specialization scales were measured to investigate H5. In addition, the task variety, task significance, task identity, skill variety, interdependence (initiated and received), interaction outside organization, ergonomics,[5] and work condition scales from the WDQ were assessed for exploratory purposes.

At both T1 and T2, participants reported how frequently they worked from home in the last days and weeks using a scale ranging from 1 = *never* to 5 = *almost always/always*.[6] This repeatedly measured indicator served as our primary telework intensity operationalization. As portrayed in our theoretical background, many theories and studies in the literature attributed change in job characteristics to media usage and face-to-face interaction frequency of the employees (as a byproduct of telework). To also consider technology related change, survey participants additionally reported at both time points how often they used five modes of communication for interacting with their work colleagues using a 7-point frequency scale ranging from 1 = *never* to 7 = *always* (face-to-face, videoconferencing, telephone, instant messaging/chat, and email). Following a procedure described by Ganesh and Gupta (2010),[7] a virtuality index was computed (an aggregate of technology use and media richness). This index allowed us to investigate if change in virtuality covaries with job characteristics change.

Our dataset obtained from an online panel provider allowed us to use Big Five personality variables as measured several years before the pandemic as control variables. Specifically, three Big Five assessments were available in the panel records. Two of the assessments were based on a 30-item Big Five measure (German adaptation of the NEO − FFI, Körner et al., 2008) and were recorded in the years 2017 and 2018. The third assessment was based on a 21-item short version of the Big Five Inventory (BFI-K, Rammstedt & John, 2005; measured in 2017). Contrary to the preregistration plan, the 30-item Big Five inventory was preferred over the 21-item version due to having a lower percentage of missing data and a higher number of indicators per Big Five construct. The 30-item Big Five measure as measured in 2018 served as the primary assessment instrument due to being the most recent one. In the presence of missing data on this measure, values were replaced with the 2017 assessment. A 5-point rating scale (1 = *strongly disagree* to 5 = *strongly agree*) was used for each item. For ~38% of the participants, no 30-item Big Five measure was available.

Besides the substantive measurements, several additional work-related questions were included in the survey: Specifically, and as preregistered, individuals were asked at T1 how frequently they worked from home before the pandemic. In addition, at both T1 and T2, questions were included that asked for the employment status of the individuals and if they were able to work during the pandemic. At T2, respondents were asked if they changed their employer from T1 to T2. The additional indicators were used to exclude participants from the main sample (see above) and were not preregistered.

Some additional questionnaire items were assessed after administering the WDQ that are not of interest in the current study (see preregistration for details).

Analytical strategy

As pointed out in a recent organizational research methods article by Breitsohl (2019), structural equation modeling (SEM) offers several advantages over more traditional and more restrictive methods such as analysis of variance (ANOVA). For example, SEM allows measurement errors to be taken into account and provides the opportunity to test measurement models as well as measurement invariance of the indicators of a construct using model fit criteria (Breitsohl, 2019). Given the numerous advantages of SEM over ANOVA, we departed from the preregistered analysis plan and based all analyses on SEM. Furthermore, the telework intensity indicator was treated as a metrical measure and was *not* dichotomized (i.e. teleworking versus not-teleworking).
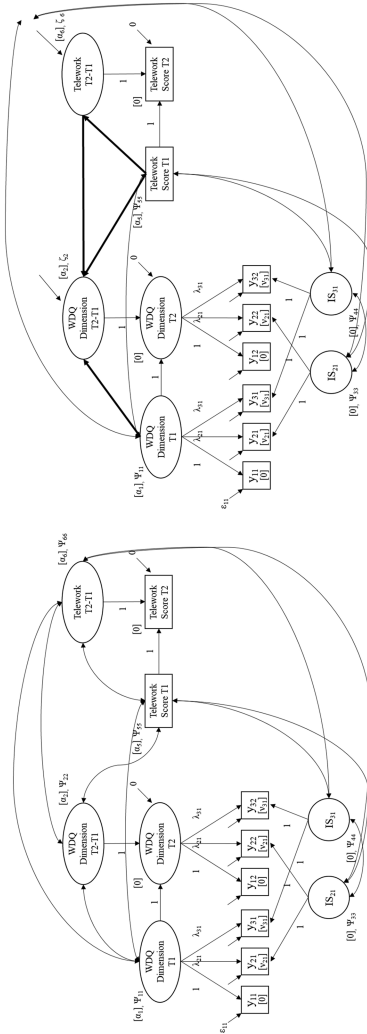
A 7-step modeling procedure was used to test our research hypotheses. For each WDQ dimension, a series of latent variable models was estimated. Prototypical models are depicted in Figure 1. We used common model fit criteria to decide on the adequateness of a SEM: Values of the Comparative Fit Index (CFI)$\geq$.95 (Hu & Bentler, 1999), (2) a root-mean-square error of approximation (RMSEA)$<$.08, preferably $<$.05 (Browne & Cudeck, 1993; Schweizer, 2010), and (3) a Standardized root-mean-square residual (SRMR)$<$.08 (Hu & Bentler, 1999) were considered as acceptable. For some models, as described below, additional criteria were used to evaluate model fit. The R package lavaan was used to fit all models (Rosseel, 2012) and robust maximum likelihood estimation (MLR) was chosen to account for non-normality (West et al., 1995). In the following, we will describe each step in detail.

Step 1: A multi-state model with indicator-specific (IS) factors was established for each WDQ dimension (see Eid & Kutscher, 2014; Geiser et al., 2010). Only n-1 IS factors ($n =$ number of items per time point) were included as suggested by Eid et al. (1999; see also Eid & Kutscher, 2014; Geiser et al., 2010). The IS-1 approach requires a reference indicator to be set for which no IS factor is established. The reference indicator was identified by permuting the reference indicator in the multi-state model and comparing the RMSEA values for each possible model. For instance, three models were estimated for a three-item WDQ dimension (e.g. work scheduling autonomy). The reference indicator model that showed the lowest RMSEA was chosen as the final model (West et al., 2012), and model criteria CFI, RMSEA, and SRMR of this final model were checked for adequateness. If two models could not be differentiated by RMSEA values, we computed the $\chi 2$/df ratio and preferred the model with the lower ratio (Schermelleh-Engel et al., 2003). For the initial configural models, the loading of the reference indicator on the WDQ dimension was set to 1, and their intercepts were set to 0 at both time points. For the IS factors, the first loading was set to 1. All other loadings and intercepts were freely estimated. Because the free loadings on the IS factors are not identified when the IS factors are uncorrelated and cause estimation problems when the correlations are close to 0, the loadings of the IS factors were set to 1 in applications with low correlations between IS factors (see Geiser et al., 2010).

Step 2: Drawing on the final model of Step 1, the loadings of the non-reference indicators were set to equality across time. All IS factor loadings were set to 1 (if not previously done). Contrasting this model against the final configural model of Step 1 with a chi-square difference test was used to examine the assumption of metric measurement invariance (Meredith, 1993; Widaman et al., 2010). In the case of a significant difference test, we tried to establish *partial* metric measurement invariance by freeing specific loading constraints (Steenkamp & Baumgartner, 1998).
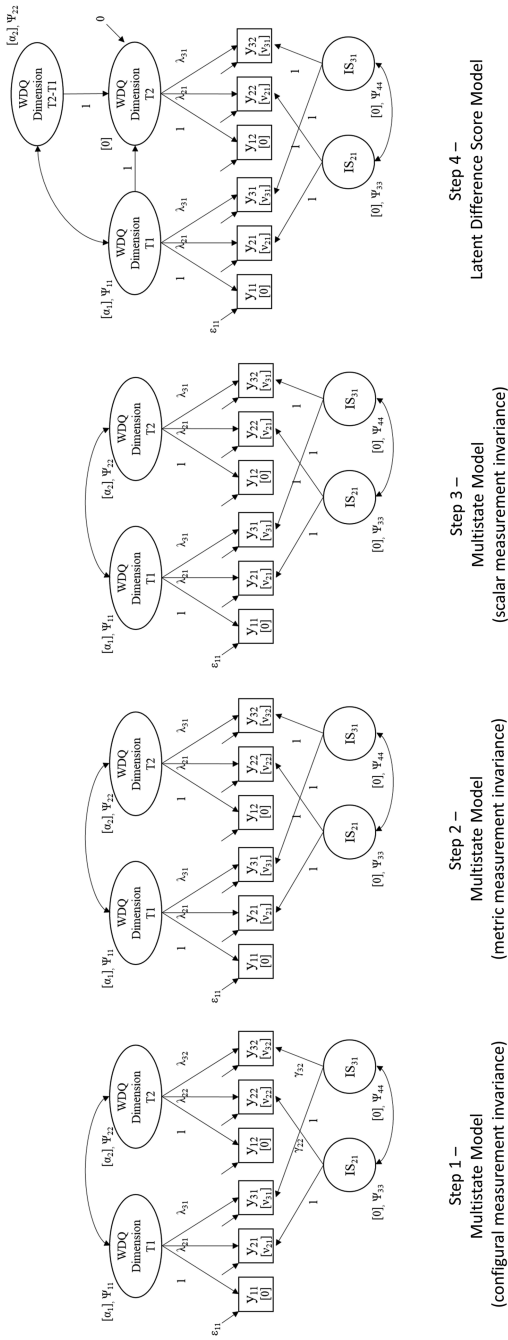
FIGURE 1 Seven steps for investigating the research questions. Step 1–3: Identifying the best fitting reference-indicator based on a multi-state model and testing for (partial) metric and scalar measurement invariance. Step 4: Reformulation of the multi-state model into a univariate latent difference score model. Step 5: Introducing a second difference score for telework into the model (bivariate latent difference score model). Step 6: Reformulating the bivariate latent difference score model into a latent regression model. Step 7: Latent regression model with the Big Five as covariates (regression arrows of personality variables were merged to avoid clutter). *Note for all Figure parts*: Not all model parameters are depicted to avoid clutter; prototypical models are depicted, the number of items per WDQ dimension, the reference indicator, and the level of invariance varied (see Table 3); λ = item-loading on state factor; γ = item-loading on indicator-specific factor; $[\nu]$ = item intercept; $[v]$ = item residual (error) variable; $[\alpha]$ = factor mean; Ψ = factor variance; ζ = factor disturbance; please note that we did not differentiate between manifest and latent factor variance/means/disturbances in the notation; WDQ = work design questionnaire; T1 = time point 1; T2 = time point 2; OCEAN = Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism.
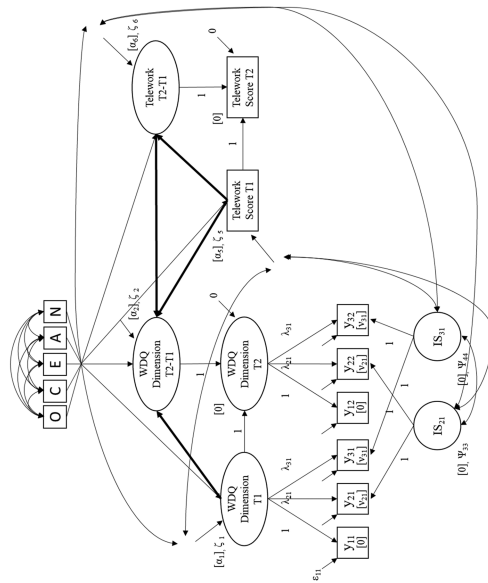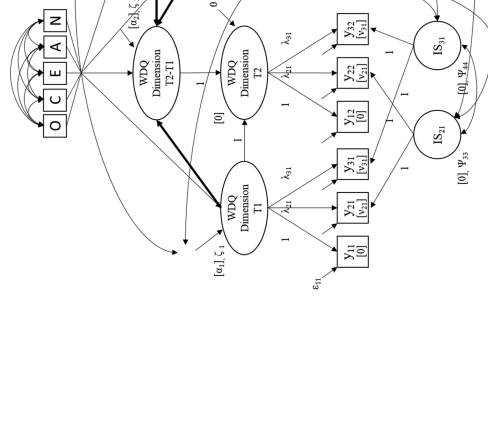
FIGURE 1 (Continued)

Step 3: The intercepts of the non-reference indicators were set to equality across time and the latent means were estimated. Contrasting this model against the model of Step 2 with a chi-square difference test was used to examine the assumption of scalar measurement invariance (Meredith, 1993; Widaman et al., 2010). In the case of a significant difference test, we tried to establish *partial* scalar measurement invariance by freeing specific intercept constraints (Steenkamp & Baumgartner, 1998).

Step 4: The multi-state model was reformulated into a latent difference score model, also called a latent change model (Eid & Kutscher, 2014; Steyer et al., 1997). This model is data equivalent to the multi-state model. It allows the analysis of interindividual differences in intraindividual change as well as latent mean change in a convenient way. A Wald z-test was used to test the hypothesis that the latent mean change equals 0. Latent mean change was only investigated for those WDQ dimensions that showed (partial) scalar measurement invariance (Chen, 2007).

Step 5: The univariate latent difference score model was extended by introducing a second latent difference score for the telework intensity indicators (based on single indicators). This bivariate latent difference score model allowed the latent correlation between the telework intensity and WDQ change scores to be inspected. Correlated change was only investigated for those WDQ dimensions that showed at least partial metric measurement invariance (Chen, 2007). The Step 5 model was used to test our main hypotheses. By exchanging the telework intensity indicators with the virtuality indicators in the Step 5 model, we were also able to examine change score correlations between the virtuality index and the primary WDQ dimensions.

Step 6: The bivariate latent difference score model was reformulated into a latent regression model to correct for individual differences on the first occasion of measurement and to analyze if other variables predict individual change beyond the state on the first occasion of measurement. First, the latent change variable was regressed on the latent state variable of the first occasion of measurement to control for the prior T1 assessments (Kievit et al., 2018). Next, two additional predictors of the latent difference score of a particular WDQ dimension were considered: telework intensity at T1 and the telework intensity change variable. Again, partial or full metric measurement invariance was a precondition for this test.

Step 7: The Big Five were included in the latent regression model as control variables for the telework intensity and WDQ assessments at T1 and the telework intensity and WDQ change score variables. Controlling for these personality variables, the association of the telework intensity change score and the WDQ latent change score were re-assessed. To account for missing values, the full-information maximum-likelihood method was chosen (Graham, 2009). As before, partial or full metric measurement invariance was a precondition for using this test. For transparency, we present a table illustrating the regression coefficients of personality variables on WDQ on the first occasion of measurement and WDQ change scores and further information regarding the coefficients in the supporting information.

RESULTS

Descriptive statistics and reliability estimates for each construct per time point are presented in Table 1 (means, standard deviations, median, coefficient omega per scale [using the proce-

TABLE 2 Correlation table for the major study variables as included in the hypotheses. For a full correlation matrix, see the Open Science framework project ($n = 479$).

No.		T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Telework intensity	T1																						
2	Telework intensity	T2	.78																					
3	Work scheduling autonomy	T1	.37	.33																				
4	Decision-making autonomy	T1	.18	.19	.64																			
5	Work methods autonomy	T1	.21	.21	.61	.80																		
6	Feedback from job	T1	−.04	.04	.07	.25	.21																	
7	Social support	T1	.06	.03	.07	.20	.21	.29																
8	Feedback from others	T1	.02	.06	.03	.15	.13	.56	.46															
9	Job complexity	T1	.10	.09	.05	.14	.16	−.06	.06	−.09														
10	Information processing	T1	.13	.13	.17	.30	.35	.16	.23	.13	.58													
11	Problem solving	T1	.07	.07	.10	.30	.35	.15	.15	.13	.40	.59												
12	Specialization	T1	.03	.08	.03	.18	.20	.20	.04	.15	.32	.47	.41											

(Continues)

TABLE 2 (Continued)

No.		T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
13	Work scheduling autonomy	T2	.27	.34	.69	.48	.47	.10	.09	.03	.11	.18	.12	.07										
14	Decision-making autonomy	T2	.03	.12	.46	.64	.56	.25	.25	.18	.17	.25	.27	.19	.65									
15	Work methods autonomy	T2	.12	.17	.48	.59	.64	.19	.17	.13	.19	.26	.32	.20	.61	.77								
16	Feedback from job	T2	−.06	.03	.09	.23	.19	.58	.25	.42	−.04	.12	.08	.22	.20	.38	.32							
17	Social support	T2	.05	−.01	.06	.18	.13	.24	.68	.41	.06	.15	.12	.05	.13	.30	.24	.39						
18	Feedback from others	T2	−.03	.01	.09	.16	.14	.43	.35	.67	−.05	.09	.14	.07	.14	.27	.19	.52	.48					
19	Job complexity	T2	.12	.11	.08	.12	.13	−.12	.01	−.14	.73	.49	.31	.28	.06	.10	.13	−.07	.00	−.13				
20	Information processing	T2	.11	.12	.13	.25	.23	.06	.18	.13	.53	.65	.45	.40	.18	.31	.35	.19	.27	.15	.51			
21	Problem solving	T2	.08	.07	.10	.22	.25	.10	.04	.09	.32	.41	.69	.35	.15	.30	.36	.17	.16	.21	.28	.55		
22	Specialization	T2	.01	.06	−.05	.12	.12	.16	.03	.14	.27	.30	.28	.66	.06	.25	.26	.33	.17	.20	.20	.48	.46	

Abbreviations: No., Number; T, Time Point.

SEM results—Measurement invariance tests

The results from the SEM analyses are summarized in Table 3 (see supporting information, Sections S2–S20 for all individual SEM results). As can be seen from Table 3, for each WDQ dimension a configural multi-state model with IS-1 factors could be established that satisfied the previously specified fit criteria in Step 1.[8,9,10] Almost all of the 19 WDQ dimensions showed metric measurement invariance in Step 2 with the exception of task significance for which no (partial) metric invariance could be established. Thus, change score associations and regression effects could be investigated for 18 of the 19 WDQ dimensions. Most dimensions showed scalar measurement invariance in Step 3 except for decision-making autonomy, feedback from job, information processing, social support, and work conditions. For these scales (except for feedback from job), partial scalar measurement invariance could be established by freeing one of the intercept constraints. Thus, for almost all WDQ dimensions, latent mean change over time could be meaningfully analyzed.

SEM results—Mean change over time

Three WDQ dimensions showed a significant mean change (i.e. increase) over time in Step 4: Task variety, received interdependence, and feedback from others. These effects were very small in magnitude and are likely of minor practical importance. Furthermore, the effects did not reach statistical significance in the sensitivity data analyses, underlining their instability. No mean change was investigated for task significance and feedback from job due to failed (partial) scalar invariance tests.

SEM results—Test of Main hypotheses

In Step 5 to 7, correlated change and regression effects were investigated. Regarding Hypothesis 1, significant positive correlations between change in telework intensity and change in each of the autonomy facets (work scheduling autonomy, decision-making autonomy, and work methods autonomy) were observed. These correlations were small to moderate in magnitude (range: $r = .110$–$.243$) and thus provide initial support for H1. The regression effects of telework intensity change on the autonomy dimensions change scores as specified in Step 6 were also significant. However, after controlling for Big Five dimensions in Step 7, the effect of telework intensity change on change in work methods autonomy disappeared. While the association of telework intensity change with change in work scheduling and decision-making autonomy was stable across both the primary and the sensitivity dataset, the link between telework intensity change and change in work methods autonomy was not. In sum, our findings partially support H1.

For all other WDQ dimensions as formulated in our hypotheses, we found no significant correlated change nor any meaningful regression effect of the telework intensity change variable. Hence, there was no support for our assumptions as outlined in Hypotheses H2–H5.

Note that we observed no robust significant correlation of the change in virtuality (Ganesh & Gupta, 2010) with any of the WDQ change scores that our hypotheses addressed (see supporting information for all individual results).

TABLE 3 Results from the multistep procedure (step 1 to 7; see supporting information for all individual results).

	Work design questionnaire (WDQ) dimension	n items	Step 1 CI?	Step 2 MI?	Step 3 SI?	Step 4 Mean change T1 - T2?	Step 5 Correlated change telework intensity ←→ WDQ?	Step 6 Regression effect telework intensity change → WDQ change?	Step 7 Regression effect telework intensity change → WDQ change (controlling for big five)?
1	Work scheduling autonomy	3	y	y	y	n	y ($r=.243; p<.001$)	y ($\beta=.251; p<.001$)	y ($\beta=.244; p<.001$)
2	Decision-making autonomy	3	y	y	y[a]	n	y ($r=-.182; p<.001$)	y ($\beta=-.151; p=.002$)	y ($\beta=-.139; p=.006$)
3	Work methods autonomy	3	y	y	y	n	y ($r=.110; p=.043$)[b]	y ($\beta=.106; p=.049$)[b]	n
4	Task variety	4	y	y	y	y (LD: .088; $p=.008$)[b]	n	n	n
5	Task significance	4	y	n	/	/	/	/	/
6	Task identity	4	y	y	y	n	n	n	n
7	Feedback from job	3	y	y	n	/	n	n	n
8	Job complexity	4	y	y	y[b]	n	n	n	n
9	Information processing	4	y[b]	y	y[a]	n	n	n	n
10	Problem solving	4	y	y	y	n	n	n	n
11	Skill variety	4	y	y	y	n	n	n	n
12	Specialization	4	y	y	y	n	n	n	n
13	Social support	6	y[b]	y	y[a]	n	n	n	n

(Continues)

TABLE 3 (Continued)

	Work design questionnaire (WDQ) dimension	n items	Step 1 CI?	Step 2 MI?	Step 3 SI?	Step 4 Mean change T1 - T2?	Step 5 Correlated change telework intensity ↔ WDQ?	Step 6 Regression effect telework intensity change → WDQ change?	Step 7 Regression effect telework intensity change → WDQ change (controlling for big five)?
14	Initiated interdependence	3	y	y	y	n	n	n	n
15	Received interdependence	3	y	y	y	y (LD: .103; $p = .017$)[b]	n	n	n
16	Interaction outside organization	3 (4)	y	y	y	n	n	n	n
17	Feedback from others	3	y	y	y	y (LD: .085; $p = .035$)[b]	n	n	n
18	Ergonomics	2	/	y[c]	y	n	n	n	n
19	Work conditions	5	y	y	y[a] (b)	n	y ($r = .149$; $p = .007$)	y ($\beta = .148$; $p = .014$)[b]	y ($\beta = .133$; $p = .031$)[b]

Abbreviations: CI, Configural Invariance; LD, Latent Difference; n, no (measurement invariance?/significant effect?); MI, Metric Invariance, SI, Scalar Invariance; T1, Time point 1; T2, Time point 2; WDQ, Work Design Questionnaire; y, yes (measurement invariance?/significant effect?).

[a]Partial measurement invariance.

[b]Discrepancy between primary and sensitivity dataset.

[c]A metric measurement invariance model was established right from the beginning.

Exploratory analyses

Associations of telework intensity change with remaining WDQ dimension change

In accordance with the preregistration, we examined associations of telework intensity change with the remaining WDQ dimensions that were not part of our hypotheses in an exploratory manner (if at least partial metric measurement invariance was given). Except for work conditions, no correlated change nor meaningful regression effects of telework intensity change were found. Although there was positive correlated change between telework intensity and work conditions across both the primary and the sensitivity dataset with a small effect size ($r = .149$), the regression effects as derived from Steps 6 and 7 were not significant in the sensitivity analysis, questioning the robustness of this finding.

Job type

As suggested by a reviewer, we conducted exploratory analyses involving job type of the participants. Supporting information present means and standard deviations of the 19 WDQ dimensions as a function of job type at both time points (i.e. education, communications/media/IT industry, healthcare, financial sector/administration, other). First, we computed Cohens d for repeated measures based on the manifest scale scores (Cohen, 1988). The results highlight that there were small differences in WDQ change over time as a function of job type. For instance, education showed larger mean changes than the other job categories, on average. However, effect sizes for mean change were still small (largest $d = .34$). Second, we dummy coded the job type indicator and used education as a reference category (education showed the largest mean decrease in telework intensity from T1 to T2). We then included the dummy variables as control variables in our bivariate latent change score model of Step 5. The change score associations for education were largely in line with our overall analyses, further substantiating the robustness of the findings.

DISCUSSION

In the current study, we adopted a work design perspective and followed up on recent calls in the literature to identify potential influencing factors on work characteristics (Oldham & Fried, 2016; Parker et al., 2017). As job characteristics have been frequently associated with a variety of major criteria such as job satisfaction (Morgeson & Humphrey, 2006) and work motivation (Humphrey et al., 2007), identifying factors that are related to their change is important. Due to the pandemic, many individuals around the globe conducted home-based telework. It has been hypothesized that new work arrangements such as telework may influence job design (Oldham & Fried, 2016). Although past research has already theorized about and empirically investigated how telework relates to job characteristics (e.g. Gajendran & Harrison, 2007; Sardeshmukh et al., 2012), we identified two shortcomings of past research linking telework and job characteristics: (1) the cross-sectional character of many studies and (2) selective samples. To alleviate these shortcomings, a repeated measures design over two time points during the COVID-19 pandemic was realized to investigate how change in teleworking intensity is associated with self-reported change in job characteristics. We presented a holistic approach by measuring a broad range of task, social,

knowledge, and contextual work characteristics. The intraindividual change perspective—despite the limitations of our own design (see limitations section)—allowed us to gain a deeper understanding of the association between telework intensity and job characteristics and may allow inferring competencies that could be particularly helpful in succeeding in rapidly evolving remote work environments. Latent difference score models were used to investigate if change in telework intensity was associated with change in perceived job characteristics and we hypothesized that this would be true for autonomy, feedback from the job and from others, social support, and knowledge requirements (job complexity, information processing, problem solving, and specialization). Furthermore, analyses focusing on additional job characteristics and correlations of virtuality (i.e. change in technology usage) with work characteristics were considered. Several important findings emerged from our analyses.

First, change in telework intensity was associated with change in scheduling and decision-making autonomy only, both with a small to moderate effect size. The associations indicate that growth in telework intensity was related to perceptions of growth in autonomy to schedule and make decisions (and complementary that decline in telework intensity was related to perceptions of decline in autonomy to schedule and making decisions). The significant association of telework with autonomy is congruent with the past (mostly cross-sectional) literature (e.g. Gajendran & Harrison, 2007; Sardeshmukh et al., 2012). Thus, our findings support prior assumptions that teleworking allows for more personal control (Allen et al., 2003). Importantly, autonomy has been treated as a unidimensional construct in many prior studies (Gajendran & Harrison, 2007, and also in our own hypothesis), but our findings highlight the value of differentiating facets of autonomy (Morgeson & Humphrey, 2008): Although change in scheduling and decision-making autonomy covaried with change in telework intensity, this was not unanimously true for *work methods autonomy*. There exist several potential explanations for these differentiated findings regarding autonomy facets. As hypothesized in prior research (e.g. Allen et al., 2003; Gajendran & Harrison, 2007) the lack of direct supervision through supervisors and colleagues may allow for more freedom in scheduling of work and in decision-making. Distance might not affect the methods used quite as much though, especially in jobs that already use a lot of communication technologies even under normal circumstances.[11] Another explanation could be that employers were required to set rules regarding the tools that are allowed to be used for working (e.g. usage of specific videoconferencing tools due to data privacy guidelines). Some employers may have been responsible for providing technical equipment, which may have hindered changes in perceptions of methods autonomy when telework practices changed.

Our results on the telework–autonomy link allow us to tentatively derive skills that might potentially gain in importance in the telework environment. Autonomy has been described as both a resource (e.g. Karasek, 1979) and a demand (e.g. Kubicek et al., 2015) by authors in the literature. Regarding the demands view, Kubicek et al. (2015) stated that teleworkers "are increasingly expected to plan and structure their workday autonomously, to determine how to handle work tasks as well as to set and control work goals. Therefore, they experience *intensified job-related planning and decision-making demands*" (p. 899). As a consequence, an increase in scheduling and decision-making autonomy may require higher self-management skills in telework arrangements (see also Beham et al., 2015; Hertel et al., 2006). Based on the demands view, we hypothesize that learning to self-manage could potentially be an important skill for people who experience the higher autonomy as demanding. From a personnel development perspective, we hypothesize that self-management training (Frayne & Geringer, 2000) may be a viable tool to help teleworkers cope with autonomy demands. In future research, it could be worthwhile to develop self-management training that especially addresses techniques to help

improve scheduling and decision-making in remote work settings (e.g. by using specialized media tools or apps).

A second important finding was that—contrary to our expectations—there was no robust association of telework intensity change with any other work characteristic change when controlling for the Big Five and re-estimating models using the sensitivity dataset. This is an important finding, because it challenges prior research that assumed a variety of positive and negative effects of telework on job characteristics beyond autonomy (Charalampous et al., 2019; Morganson et al., 2010; Sardeshmukh et al., 2012). Although we expected negative associations of change in telework intensity with change in social characteristics (i.e. social support, feedback from others) and feedback from one's job, our data did not support these assumptions. This is surprising, because past research assumed "that remote working is usually detrimental for the relational aspects of work" (Wang et al., 2021, p. 21). One explanation might be that the emergence of new media tools (e.g. Slack) dampens the potential negative effects of telework, because they allow face-to-face feedback to be substituted. Alternatively, individuals may proactively seek out feedback and support, compensating for any negative influence of reduced physical co-presence (see also Allen et al., 2003). Overall, there was marginal mean change in social support and feedback over the course of our study, on average (but note that the exploratory analyses revealed some dependency of these findings based on the type of job of the study participants). Stronger negative change in social support and feedback may have occurred at later time points during the pandemic (e.g. during the second lockdown in Germany) due to fatigue effects not captured by our measurements. Of note, there is substantial variability in the association of telework on social characteristics that have been reported in past studies (Gajendran & Harrison, 2007). Whereas high telework intensity was associated with negative co-worker relationship quality, there was even a positive relation of telework to the quality of the employee-supervisor relationship (Gajendran & Harrison, 2007). The "social support" scale as integrated in the WDQ includes items with reference to supervisors, work colleagues, and generic "other people" or "others". Likewise, the "feedback from others" scale consists of items with reference to supervisors, work colleagues, and other people from one's organization. Aggregating over these items may cancel out relevant interaction-partner specific variance. In future research, new scales could be constructed that add frames-of-reference (e.g. using item-tags; Lievens et al., 2008) to "social support" and "feedback from others" items of the WDQ in a more systematic way in order to construct interaction-partner specific WDQ scales (see Schulze et al., 2021 for a similar reasoning in the personality literature). For instance, the social support item "People I work with take a personal interest in me" (Morgeson & Humphrey, 2006, p. 1338) could be augmented with context-tags that explicitly frame respondents as work-colleagues and supervisors instead of as people in general. These items would allow the investigation of whether potential associations of telework intensity on social characteristics should be differentiated by interaction partners.

Interestingly and counter to our hypotheses, we also did not find a significant link between telework intensity change, and knowledge characteristics change. Although it was argued that heightened technical problem-solving competences could be needed while teleworking (e.g. Topi, 2004), today's knowledge workers may have gained considerable experience in using new technologies over time, thus not perceiving much of a difference in knowledge requirements while changing their teleworking activities. It is also possible that telework intensity plays a minor role in the context of knowledge requirements: Once an individual starts teleworking (independently of intensity), media competencies (e.g. for using videoconferencing software) will be required. Computer-mediated communication competencies and media experience

(Spitzberg, 2006) could be measured in addition to telework and job characteristics indicators to examine this question in more depth.

Lastly, our analyses showed no meaningful association of the change in virtuality with change in any work design dimension that was part of our hypotheses. The virtuality index was adapted from Ganesh and Gupta (2010) and weighted usage frequency of different media with richness ratings obtained from six raters. As prior research discussed the potential relation of technology features (e.g. richness) and technology usage to job characteristics (e.g. Gajendran & Harrison, 2007), this ancillary analysis provides useful information on the technology use-job characteristics linkage. Recently, researchers have called for virtuality measures that do not only focus on the objective properties of virtuality (e.g. media characteristics, richness), but incorporate subjectively experienced facets of virtuality (e.g. *team perceived virtuality* as outlined by Handke et al., 2021, in the context of virtual teamwork). Richness may lie in the eye of the beholder and could be influenced by the media experience of users (as outlined in *Channel Expansion Theory*, Carlson & Zmud, 1999). Future research may benefit from incorporating subjective aspects of virtuality to examine their association with work characteristics (e.g. as in Costa et al., 2021).

Limitations

Our study design is limited in several ways: (a) Although an improvement in comparison to cross-sectional research (Ployhart & MacKenzie, 2014), our two time point repeated measures design is not able to capture nonlinear relationships such as curvilinear change. (b) The time spacing of the two times points may not have been optimally chosen (Dormann & Griffin, 2015). For example, certain phenomena (e.g. perceptions of reduced social support or feedback) may have unfolded after our second measurement time point. (c) No baseline measures before the pandemic were captured. Therefore, no pre-pandemic baseline levels could be considered in our analyses (Zacher & Rudolph, 2022). It would have been valuable to investigate how growth in telework intensity (as a response to the lockdown) related to potential job characteristics change. (d) Unmeasured and unmodeled variables may still act as confounds in our study. To address these issues, extensive within-person designs in the form of diary studies (e.g. as in Vega et al., 2015) could be combined with longer-term measurements to provide a more complete picture of correlated change between telework intensity and job characteristics. Furthermore, a larger number of control variables could be measured and included in the regression model or methods such as propensity score matching could be used to better infer causality in future research (Zacher & Rudolph, 2022).

There was only a small to moderate change in self-reported telework intensity from T1 to T2 and a relatively high proportion of traditional workers. Although no strict lockdown was imposed at the time of the second assessment, the COVID-19 pandemic was still ongoing and restrictions such as mask-wearing in public transportation were still in place. Self-imposed face-to-face contact limitations (Teslya et al., 2020) at the second measurement time point may be one reason for the overall small to moderate changes in telework intensity. The telework intensity changes could have been too small to elucidate meaningful change in job design dimensions. Research has called for a more nuanced, frequency-based view on telework. For instance, Allen et al. (2015, p. 45) noted that "a person who telecommutes one day per month is likely to have different experiences than a person who telecommutes four days per week". Analogously, the average change in telework intensity as reported in this study might have

been too small to impact change in work design perceptions, calling for future research with larger changes in telework intensity. Similarly, the average change in virtuality was small in magnitude and the retest correlation high, indicating similar technology usage at both measurement points.

Although the pandemic allowed us to investigate associations of telework intensity change with change in work design dimensions, the generalizability of the findings to future telework contexts might be questioned. Regarding this limitation, Carillo et al. (2021, p. 71) contrasted characteristics of "conventional telework" and "epidemic-induced telework". The authors pointed out that telework during the pandemic was often mandatory and the implementation happened suddenly compared to the conventional pre-pandemic telework implementation (see also Waizenegger et al., 2020). The context of the pandemic could have impacted the representativeness of our sample. Zacher and Rudolph (2022) cautioned readers that a crisis could impact who participates in research surveys (e.g. healthy individuals who are not affected by the coronavirus). Thus, the context of the pandemic may limit the generalizability of findings and calls for post-pandemic longitudinal studies. Future studies should also investigate the generalizability of our findings to additional job characteristics that are frequently related to telework (e.g. work–family conflict, Darouei & Pluut, 2021).

Multiple indicators per construct-time unit were modeled only for the WDQ dimensions, but not for telework, virtuality, and personality. This means that measurement models were not tested, and error variance not separated from true score variance, which may influence the results in unpredictable ways (Cole & Preacher, 2014). Future studies may incorporate multiple items to measure telework activities and use personality tests that allow for modeling well-fitting measurement structures. However, personality tests have a long history of showing problematic model fit using classical confirmatory factor analysis (e.g. Borsboom, 2006; Gignac et al., 2007; Vassend & Skrondal, 2011). Furthermore, each of the WDQ dimensions was treated independently from the other WDQ dimensions in the latent variable models. A full latent variable model (with all WDQ dimensions at both time points, telework indicators, indicator-specific factors, and personality variables) would have included an unmanageable number of variables given our sample size. We acknowledge that the decision to reduce model complexity comes with its own limitations such as an isolated view on each WDQ dimension. In future studies, larger sample sizes are needed to fit such a complex latent variable model.

The personality measures were based on panel records collected in the years 2017 and 2018, whereby the 2018 measure served as the primary instrument. Whenever possible, missing 2018 personality scores were replaced with measurements collected in 2017 (also measured with the questionnaire by Körner et al., 2008). Although we consider this strategy reasonable, future studies might collect personality data for all individuals at the same time point so as not to potentially introduce confounds due to the different time of administration. However, the data collection at different time points also had advantages: First, participants took part in two short assessments rather than one long assessment, which due to smaller respondent burden probably increased the measurement's reliability. Second, the time-spaced and independent assessment prevented content-related spillover across the two domains of assessment, thus potentially increasing the measurement's validity.

Finally, despite being preregistered, we did not follow the proposed analyses and measures in every respect (see https://osf.io/ayg6n/ for transparent changes document). Although these decisions were made to increase the quality of the study, they make the research more exploratory than originally intended, and this should be borne in mind when interpreting the inferential tests.

CONCLUSION

Following calls to identify antecedents of work design, we investigated the association of change in teleworking intensity with change in job characteristics. A repeated measures dataset (two time points) was collected in Germany at the time of the COVID-19 pandemic. Although many potential effects of telework on job characteristics have been proposed in the literature, we did not find much evidence for strong beneficial or detrimental effects. In fact, change in telework intensity was associated only with work scheduling autonomy and decision-making autonomy. Thus, the current study challenges and extends prior research and calls for studies that investigate the generalizability of our findings to non-pandemic work contexts.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest.

ETHICS STATEMENT

We have complied with the American Psychological Association's ethical principles regarding research with human participants when executing the study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in the associated Open Science Framework project: https://osf.io/ayg6n/.

ENDNOTES

[1] Please note that we did not differentiate between facets of autonomy in our hypothesis, but that the WDQ includes three different types of autonomy (scheduling, decision-making, and work-methods autonomy; Morgeson & Humphrey, 2006). Our hypothesis involving autonomy was conceptualized to broadly refer to all three types of autonomy.

[2] Please note that we reworded the preregistered hypotheses for the current study. This was done for two reasons: First, it was not foreseeable for us in April 2020 (the month of preregistration) that the COVID-19 pandemic would continue far beyond the autumn of 2020. Specifically, we reasoned that "most of these workers will – when the Corona outbreak is dealt with – transition back into their usual work routine" (see preregistration document). However, employees did not necessarily return to their standard working habits at our second measurement time point and the COVID-19 pandemic is continuing until today. Second, our methodological approach (latent difference score models) that we chose to improve the statistical analyses (using latent measurement error free variables), focuses on *change* score variables (representing a continuous rather than a dichotomous view on telework that better fits the repeated measures design of our study and contemporary perspectives on telework intensity). The direction of the adapted *correlated change* hypotheses is the same as in the original preregistered hypotheses and they focus on the same constructs.

[3] The original raw data file consisted of $n = 7554$ rows. This number corresponds to the number of invitations that were sent to panel members. $n = 6169$ were empty rows (= no reaction to the invitation) and were excluded from the datafile. To guarantee anonymity of participants, qualitative responses were deleted from the uploaded file.

[4] We multiplied 2 s with the number of survey indicators to arrive at the minimum duration to complete the survey. We acknowledge that this criterion is a rougher cut-off criterion than truly setting a 2-s per item cut-off within the survey.

[5] We did not measure the ergonomics item "The job involves excessive reaching" in our study (Morgeson & Humphrey, 2006, p. 1339).

[6] Please note that we did not preregister the exact wording of this indicator.

[7] A panel of six raters who are familiar with the concept of media richness (Daft & Lengel, 1986) were instructed to rate the richness of face-to-face, videoconferencing, telephone, instant messaging/chat, and email communication. They assigned a score of 1 for a particularly rich medium and a 7 for a medium that is very low on the richness dimension (1–7 scale). The scores were aggregated across raters to arrive at a medium's average richness (MW face-to-face: 1.17; MW videoconferencing; 2.17; MW telephone: 3.17; MW instant messaging/chat: 4.83; MW E-Mail: 6). Frequency scores given by participants were weighted by the average richness ratings (by multiplying a particular frequency score with the corresponding average richness rating) and the resulting scores were summed over the communication modes, resulting in a virtuality index (see Ganesh & Gupta, 2010, for further details). The index could vary from a minimum of 17.34 (using all modes with low frequency) to 121.38 (using all modes with high frequency).

[8] For the WDQ dimension "Interaction Outside Organization", no configural model with all four indicators could be established—likely because of the similar wording of some of the items. Dropping one of the similarly worded indicators resulted in a three-item configural measurement model that satisfied all fit criteria and that showed metric and scalar measurement invariance over time.

[9] Because only two indicators per time point were available for the ergonomics dimension, a measurement model with equal loadings (metric measurement invariance) was established right from the beginning.

[10] In rare cases (Information Processing, Social Support) there was disagreement between the main dataset and the sensitivity dataset as to which reference indicator showed the best fit. In these cases, the solution of the main dataset was preferred.

[11] We thank a reviewer for providing this potential explanation.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.