

The Registration Continuum in Personality Disorder Studies: Theory, Rationale, and Template

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Registration is a tool to increase the rigor of personality disorder research and its ability to reduce human suffering through improving people's lives. This article details the problems that exist without registrations, which revolve around a study's outcomes' dependence on the data rather than on the theory being tested. Registrations exist on a continuum underpinned by bipolar timing and unipolar disclosure dimensions, the latter of which poses myriad points of decisions for researchers to register. The registration process provides memory aids and guideposts for researchers through the course of a study, transparently maintains public trust in the scientific enterprise, and preserves the severity of the tests used in the study. This article provides a template for personality disorder researchers to consider and examples of how researchers can use registered flexibility to plan for contingencies that might arise during a study. It also addresses challenges in evaluating registrations and implementing registration in a research workflow.

Keywords: preregistration, coregistration, postregistration, transparency, severity

Personality disorder research promises to help suffering people understand themselves better and provide them with tools to improve their lives. However, it is easy for researchers to make decisions that serve their citation counts or grant funding more than ameliorating the problems people have. One method of both increasing the rigor (Soderberg et al., 2021) and delivering on the promise of personality disorder science is study registration (Verschuere et al., 2021). Registration entails uploading the components of a study to an independent, publicly accessible site that time stamps each upload, which allows people outside the research team to verify the timing of each prediction relative to when data are collected or analyzed. This article details the problems that exist without registrations, which revolve around a study's outcomes' dependence on the data rather than on the theory being tested. Registrations exist on a continuum underpinned by bipolar timing and unipolar disclosure dimensions, the latter of which poses myriad points of decisions for researchers to register. The registration process helps researchers conceptualize their studies more thoroughly, preserve the strictness of the tests used in the study, and maintain public trust in the scientific enterprise. Nevertheless, registrations are not a panacea for scientific malpractice,

and verifying registrations is one of the most vexing problems in open science research.

Problems With Unregistered Personality Disorder Research

Many of the potential problems with closed personality disorder research entail researchers making decisions based on the data they collect rather than the descriptive phenomena or theories that motivated the studies (Srivastava, 2018). Researchers can traverse an analytical garden of forking paths (Gelman & Loken, 2014), leading to such questionable research practices as selective recruitment stopping, data removal, or reporting of variables or analyses—the effects of which are all the more pronounced in risky scientific endeavors (Ulrich & Miller, 2020). Sometimes, researchers may choose alternative data transformations or statistical models because the original analytic plan did not yield the desired results. They may also conduct analyses on particular subgroups of participants or trials in the absence of statistically discernible interactions that would render such follow-up analyses reasonable (Wagenmakers et al., 2011). These changes to any study's conduct undermine the diagnosticity (or the correspondence of the test's actual error value to its claimed error value) of the resulting p values or Bayes factors. In the case of p values, multiple examinations of data sets inflate the false positive rate to an unknown degree, as it remains unclear how related each set of peaks or analyses might be. In Bayes factor denominators, the probability of a positive statistical test result is no longer calculable when undisclosed peaks or analytic changes are undertaken.

With unregistered flexibility, researchers can alter the theoretical frameworks of their studies behind the scenes, which allows for fraud. Instead of *predicting* a result, researchers can create a convoluted just-so story that *postdicts* unexpected results that

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arose from a study. This process reflects hypothesizing after results are known (Kerr, 1998), leading to research programs that create unfalsifiable balls of ad hoc adjustments to preserve the cores of initial theories. This spiral is a hallmark of what Lakatos (1978) described as a degenerate research program, one that fails to generate scientific progress in favor of justifying an initial set of beliefs. Productive research careers derail through intensive efforts to maintain such research programs, and the scientific literature becomes distorted with unreplicable, unwieldy theoretical and empirical morasses. In extreme cases, researchers may end up fabricating data to provide evidence for their hypotheses (Marcus, 2021). This fraud is especially harmful in personality disorder research, which relies on robust, well-studied theoretical frameworks to justify the utility of the disorder constructs. If the personality disorder literature is tainted by such quagmires, the lack of consensus or clarity can translate into ineffective or even harmful clinical practices. When such research is used to justify industry standards and public policy interventions (Lee, 2021), the harms of unregistered research spread across society. Such untrustworthy research harms the public's trust in the scientific enterprise, threatens the well-being of patients, and jeopardizes research's epistemological foundations.

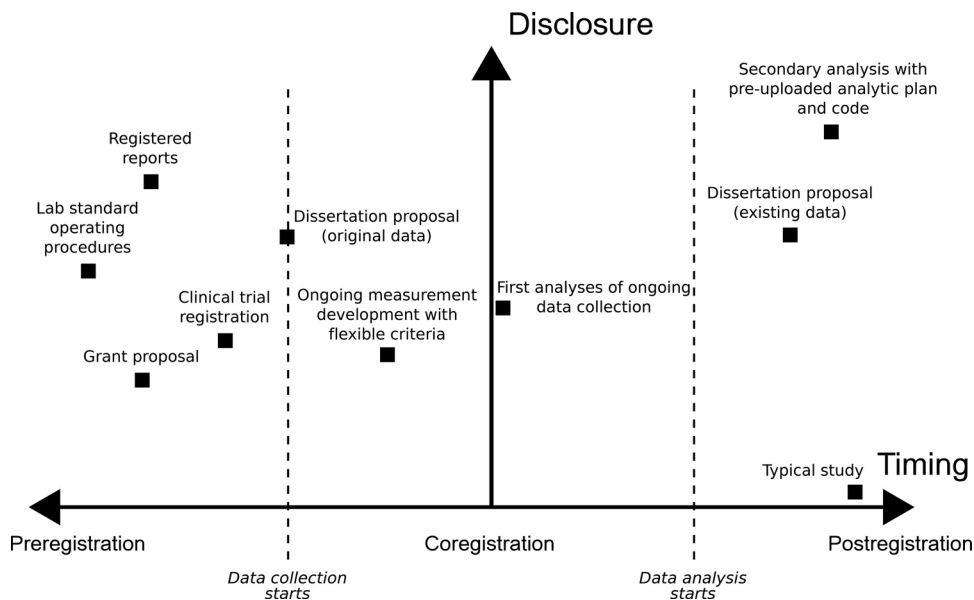
The Registration Continuum as a Way Forward

Study registration encompasses two fundamental dimensions displayed in Figure 1 the *timing* of the registration relative to the start of data collection or analysis and the amount of *disclosure* about a study's proposed activities (Benning et al., 2019). In this model, the bipolar timing axis is centered on the moment that data

collection starts. Registrations that are placed in a repository before data collection starts are properly termed *preregistrations*. Preregistrations afford researchers maximum independence of their activities from the data they collect—and thus from the temptations to use those data to fashion a story most conducive to a researcher's presuppositions. Investigators are free to pre-register both the methods they intend to use and the theory driving those methods, as might be found in a registered report or a proposal for a student's thesis or dissertation. Articulating the theoretical framework surrounding a study in a preregistration permits researchers to consider their auxiliary hypotheses and assumptions.

Coregistrations occur when a registration is posted while data are being collected but before focal tests of the study's aims are conducted. They may be preferred to preregistrations when time is of the essence or when the study requires modifications to its procedures to maintain fidelity to the study's broader goals. Coregistrations require more detail than preregistrations, as both the initial procedures and their modifications must be detailed; registering the empirical or theoretical justifications for those changes bolsters their credibility. *Postregistrations* occur after a registration is posted when a study's data have already been inspected, most often in the course of secondary data analyses (Weston et al., 2019; see van den Akker et al., 2021, for a postregistration template). Postregistrations provide an opportunity for researchers to address limitations of the data set (e.g., demographics, measures used) ahead of the peer review process, thereby allowing subsequent criticism to focus on discussion of the broader theoretical framework of the study, rather than problems with specific details of the data. They require the highest level of justification for proposed

Figure 1
Diagram of the Registration Continuum



Note. Squares indicate locations of example registrations in the time-disclosure continuum. Preregistrations occur before data are collected, coregistrations after data collection starts but before data analysis begins, and postregistrations after data analysis has begun. Describing more features of a study's design in a registration would earn it a higher score on the disclosure axis. Figure by Stephen D. Benning; available at <https://doi.org/10.6084/m9.figshare.8141975.v2> under a CC-BY4.0 license.

analyses, as researchers must demonstrate that their analytic plan is supported by a strong theoretical framework and not the result of hidden, precompleted statistical tests.

The unipolar disclosure axis of the registration continuum refers to how much information a registration divulges. The more aspects of a study that are registered, the more transparent the registration effort is and the more readily a study's outputs can be compared with that registration. Registering a study in greater detail also speeds the writing of manuscripts from that study. The information from registrations can be repurposed ethically into manuscripts through developmental recycling (Moskovitz, 2021), particularly in method sections (Moskovitz & Hall, 2021), as the purposes of the registration and publication are distinct but require textual repetition to ensure fidelity to the meaning of the registration (Pieper et al., 2021). Researchers may be concerned that excessive disclosure will lead to their ideas being appropriated by other teams. Though this is rare in practice, registrations may be made private in many repositories, visible only once the review process has begun on study manuscripts. Furthermore, with time-stamped registrations available in a repository that researchers do not control, those who have the first registration can claim primacy of the ideas contained therein (Klein et al., 2018). The registration process can therefore help to protect the intellectual property of researchers.

Benefits of Registrations in the Upper Left Section of the Registration Continuum

Generating Memorial Aids

In this framework, registrations occupying the upper left portion of the continuum are most desirable because they constrain researchers' degrees of freedom (Simmons et al., 2012) in their studies, maintaining studies' diagnosticity (Wagenmakers et al., 2012). As described earlier, researchers can take advantage of idiosyncrasies in their data without such constraint, telling a preferred story at the cost of distorting the evidential value of their studies. However, nefarious motives need not be at play when analytic plans or models change from a study's inception to its conclusion. Without documentation, researchers likely forget some of the myriad details that comprise a study. Registrations both preserve the decisions a research team made at the start of a study and provide a roadmap to transforming raw data into polished analyses that most faithfully carry through those initial decisions. The earlier these decisions are registered in greater detail, the less researchers must reconstruct trains of thought after a study has concluded. Such registrations therefore also reduce the risk of procedural errors that could otherwise unduly influence the study's results and go unnoticed by the research team.

Ensuring Epistemological Severity

From an epistemological perspective, these transparent constraints provide the most severe tests of a study's hypotheses (Lakens, 2019). *Severity* refers to the strictness of a test's ability to uncover any flaws in a particular hypothesis and falsify that hypothesis (Mayo, 2018). In the weak form of severity, a test cannot assess a hypothesis if the test is incapable of falsifying that hypothesis; in the strong form of severity, a hypothesis passes a test that is strongly able to falsify that hypothesis. In psychology,

statistically discernible results are found less than half the time in registered reports, whereas they are found more than 95% of the time in unregistered reports, a pattern that highlights the severity of tests in registered research (Scheel, Schijen, et al., 2021). When studies are registered, the auxiliary hypotheses that support a focal test (Meehl, 1978) are explicated, allowing researchers to examine whether their study's design can even support the test they propose. Researchers may recognize that the phenomenon they wish to test is insufficiently specified to allow severe tests, prompting them to orient the study more descriptively (Scheel, Tiokhin, et al., 2021). These descriptions may entail quantitative characterizations of personality disorder symptomatology (Krueger et al., 2012), the situations that elicit or maintain those symptoms (Rauthmann & Sherman, 2016), the interpersonal dynamics at play (Wright et al., in press), and the boundary conditions of the tested theory (Simons et al., 2017). However, if these are not sufficiently clear when a study is proposed, qualitative methods may be needed to elucidate the relevant personality disorder phenomenology (Hurlburt, 1993; Ng et al., 2019). Through the registration process, researchers can adopt an appropriate framework in which these inclarities are dealt with before the study launches.

Preserving Trust in the Fidelity of Scientific Work

Registrations in the upper left portion of the continuum also maximize transparency about the decisions that researchers make regarding their studies (Gernsbacher, 2018). When researchers publicize their theories, data gathering, and analytic plans in advance of running the first participant, they set a standard for themselves to follow in their subsequent work. Doing so in advance of data collection also ensures the independence of their decisions from the results that obtain from the study's efforts. This procedure can also guard against acquiescing to reviewer demands to alter a study's theoretically derived analytic plans, a circumstance called criticizing after results are known (Nosek & Lakens, 2014). Resolving criticism surrounding data analyses prior to data collection both strengthens study designs and allows more room in the peer review process for discussion of theoretical implications and future directions. Even if plans need to change, registrations provide a foundation on which to build updates. Coreregistrations can be used to update preregistrations in a way that maintains transparency about the original research plan along with the reasons that plan needed to be altered. Researchers can even preregister plans to resolve foreseen complications before seeing a study's data and use version control of registrations to maintain a clear through-line of changes. The extent to which researchers are able to anticipate potential issues that could arise in a study's conduct and nimbly deal with unanticipated problems could also be a hallmark of scientific eminence (Simonton, 2016).

What Kinds of Details Can Be Disclosed in Registrations?

The APA's Journal Article Reporting Standards provide an excellent starting place to consider the study information to register (Bosnjak et al., 2022). The method sections of these guidelines deserve parsing for either quantitative or qualitative studies, as the study's method is the heart of the registration. Moreover, the Journal Article Reporting Standards for introductions highlight the importance

of registering hypotheses, both the focal tests of interests and the potential auxiliary hypotheses whose falsifications would reduce the severity of the tests. Below, we describe the kinds of details that personality disorder researchers would profit from considering across different types of registrations. The more details are registered, the higher the registration would score on the disclosure axis of the registration continuum. Table 1 organizes these details into an easily browsed template.

Participant Sampling Frames and Stratification Rules

In personality disorder research, it is important to know from what sampling frame participants will be drawn, the methods

used to obtain that sample, and criteria for inclusion or exclusion; these elements of registration are given in Row 1 of Table 1. Commonly sampled populations include convenient undergraduates, clinical patients, prescreened individuals from the community, and inmates within a forensic facility. These might be recruited using online portals, panels, flyers, snowball sampling, or contact with clinicians. The source of participants allows a registration to anticipate the expected levels of personality symptomatology in the sample. The demographic units used to stratify a sample should also be detailed. For instance, researchers should specify whether particular proportions of racial or ethnic groups are to be recruited. Other possibilities include specific age groups in developmental studies and overrepresentations of extremes of a

Table 1
Template for Registering Personality Disorder Studies

Domain	Preregistration	Coregistration	Postregistration
Sample	• Sampling frame and method • Targeted sizes of each group (with power or sensitivity analyses) • Inclusion criteria • Exclusion criteria • Plans for participant replacement	As in preregistration and • Tweaks to sample catchment, size, or method based on feasibility	• Methods and <i>sources for obtaining data</i> • Extent of <i>database to use</i> • Rules defining specific cases to use in existing data set
Measures	• <i>All measures in study</i> • Assessment frequency • Identification of predictors and outcomes • Identification of covariates • Identities of raters and data combination rules	As in preregistration and • Measures dropped due to infeasibility • Measures added to address concerns during data collection	• <i>Codebooks with variable summaries</i> • Focal measures to use • Psychometrics of measures
Manipulation or intervention	• <i>Experimental tasks, stimuli, and responses</i> • Nature of interventions • Nature and allotment of participants to treatment arms • Definitions of sufficient fidelity to manipulations or interventions	As in preregistration and • Stimuli or tasks requiring replacement • Alterations to interventions or arm assignment • Nature and frequency of refresher training	• Rules for using only certain observations • Any changes in definitions of sufficient fidelity to manipulations or interventions • Process-based data not previously registered
Study procedures	• Participant allocation • Masking of conditions • Task/measure order • <i>Data collection parameters</i> • <i>Debriefing scripts and procedures</i>	As in preregistration and • Number of raw data files inspected to verify data integrity • Alterations to data collection and reduction	• Exclusions based on failures of masking • Whether to use only data collected under final procedures or use phase of collection as factor in analyses • Methods for dealing with missing data
Data cleaning	• <i>Data reduction steps</i> • Minimum data quality standard descriptions • Recoding steps • Data transformation rules • <i>Laboratory standard operating procedures</i>	As in preregistration and • Exclusion rules for subsets of data based on study progress (e.g., program failure, fidelity problems during study)	• <i>Preexisting data cleaning scripts</i> • Differences between previous cleaning steps and those for this study • <i>Laboratory standard operating procedures</i>
Statistical analyses	• Verbal descriptions • Methods of dealing with attrition and other missing data • Multiple comparison adjustments • Model selection rules • <i>Pseudocode</i> • <i>Simulated analyses</i>	As in preregistration and • <i>Analytic code based on variable names</i> • Citations to methods papers updating details of analyses	• Details of previous analyses informing study • Results of analyses performed on similar data or subsets of current data • <i>A priori</i> specifics of statistical models

Note. Italicized entries indicate additional open science practices that can be registered.

pathological personality trait. In a multisite study, researchers should also indicate which sites might be expected to bear the different parts of the recruitment for these various groups. In a developmental study, the sampling approach (e.g., cross-sectional, single cohort, accelerated longitudinal design) should be justified. Decisions about sample composition can be registered, along with plans to align participant recruitment with the goals the study seeks if obtaining desired the stratified sample proves challenging. Overrepresenting certain groups (or eliminating a random subset of a majority group in secondary analyses) may be useful in richly analyzing differences among those groups or in powering the interprocess interactions that could uniquely define personality disorders (Lilienfeld et al., 2019), though at the cost of distorting the population to which findings might apply (Benning & Smith, 2019). Registrations can justify the scientific necessity of these distortions.

The total number of observations in a sample can also be registered as a function of the number of participants and measurement instances per participant. These design decisions may entail powering a study either to detect a specific smallest effect size of interest (Harms & Lakens, 2018) or to reduce the error of estimation of a parameter to a certain small amount. If these effects will be analyzed by groups in the sample, registration enjoins researchers to consider the size of these effects in each of these groups to justify the total number of observations. For example, researchers looking at measurement invariance of schizotypal personality disorder symptoms across particular demographic groups (Cicero, 2016; Fonseca-Pedrero et al., 2011) or the effects of societal stress on minoritized groups' paranoid personality disorder symptomatology (Iacovino et al., 2014) would need to register a sufficiently powered sample to detect these effects. That process prevents underpowered studies from camouflaging important group differences in personality disorder correlates and courses. Researchers should also register the procedure they will use to adjust for multiple comparisons and how that procedure will affect the smallest detectable effect size with the study's design. These procedures trade off strictness in error control for power to detect effects. Registering more powerful tests at the start of a line of inquiry or when starting with procedures new to a lab would maximize the probability of detecting an effect, with more stringent error control helpful when an effect's parameters are better established with a more seasoned research team.

Measures and Units of Analysis

As highlighted in Row 2 of Table 1, the measures used in personality disorder research provide the flavor of the constructs of interest, highlighting certain psychopathological features and minimizing others. Some researchers may prefer narrow measures of a particular personality disorder, whereas others may prefer broadband measures that assess a variety of personality disorders or personality processes common among personality disorders. Still others may prefer to use normal-range personality measures to estimate personality disorder as a set of extremes of normal personality functioning. Registering the measures to be used in a study and the nomological net surrounding those measures clarifies what hypotheses are reasonable for a study. To the extent possible, open measures are preferred in personality disorder study registrations, as the content of these measures is easily inspected, and their use facilitates research in locations with reduced funding. Nevertheless, certain research questions in applied

or forensic contexts may require using measures protected by test security to preserve the study's real-world utility. In such cases, it is critical that researchers register the construct validity of the protected measures.

The procedure for aggregating data from measures deserves registration. Many personality disorder measures are designed to assess latent constructs through a combination of individual items or scales. For instance, if a psychopathy measure has a controversial factor structure (Roy et al., 2021) or one that differs based on the groups being studied (Ruchensky et al., 2018), researchers can register either an *a priori* structure based on previous work or a series of procedures that will define the structure to use in the study. Alternatively, if a network of personality disorder symptoms will be examined, researchers can register the symptoms they will consider, the ways in which those symptoms will be assessed, and the parameters related to edge creation and centrality to explicate their theoretical assumptions (Bringmann et al., 2019). In qualitative studies of personality disorder, the positionality of the research team members and the protocols used to gather responses can be registered (Haven et al., 2020). For example, are responses gathered through interviews, focus groups, field notes, participative observation, archival research, or mixed methods—and by whom are these responses gathered? In any case, it is important to consider the identity of the raters of personality disorder symptomatology. Though self-reports are common in adults, romantic partners, friends, or clinicians may also report on patients' symptoms; parent or teacher reports may be more useful for younger children. The decision rules to combine data among raters at the item (Bauer et al., 2013) or scale level (Makol et al., 2020) should also be registered to clarify the researchers' assumptions behind the discrepancies among raters.

Registrations will specify which measures are predictors; which are outcomes; and which are covariates, mediators, or moderators. A study may collect many more measures than will be used to address the questions in a single article, so researchers should register which measures will be used to answer a particular theoretical issue. In doing so, they should make the causal models they are testing clear. Registering directed acyclic graphs helps researchers specify the relationships among their variables to make causal sense of observational data—or recognize what causal claims may be inappropriate given how a data set was collected (Rohrer, 2018). These formalizing processes ensure that measures are not conveniently added or dropped when initial analyses do not return the desired results; they also prevent rearrangement of the predictors and outcomes in mediational models. These processes further prevent ad hoc additions or subtractions of covariate adjustments or hidden moderators that might allow researchers to rescue the desired results of a study through *p* hacking at the cost of degenerating a research program (Wicherts et al., 2016). To the extent that data can be posted to a repository along with a registration, registrations can also advance broader open science and accessible science goals.

Study Protocols

Longitudinal Studies

Preregistrations entail detailing the procedures participants will undergo over the course of a study. In a cross-sectional study, this may require enumerating only the order in which measures will be

administered. However, longitudinal studies require additional details about each assessment period, as suggested in Row 2 of Table 1. Ecological momentary assessment studies may assess participants on an idiographic schedule, asking different questions at various points during the day to capture important aspects of the participant's social milieu or questions dependent on participants experiencing specific events (Kirtley et al., 2021). Developmental studies may assess participants in nomothetically spaced intervals with varying raters (Hamlat et al., 2020), which may require changes in instruments across study phases or developmental epochs (Stepp et al., 2016). In any case, the timing of the assessments—including the number and frequency of prompts given to participants who have not completed a specific assessment—and their content deserve preregistration. Coregistrations can update adjusted parameters of these assessments that improve the feasibility of their assessments in the field, correct unforeseen administration errors, or refine the items based on participant feedback or advancements in the assessment literature. Postregistrations of existing data can specify which assessments within an extensive battery would be used, their psychometrics, which epochs are of interest, and whether different pieces or structures of those assessments will be used in different epochs.

Experimental Studies

Within experimental studies, a wide range of parameters can be registered, as shown in Rows 3 and 4 of Table 1. When the study is being designed, decisions about the stimuli, the responses, and any contingencies between stimuli and responses can be preregistered. The stimuli that will be used, their orders and durations, the intervals between stimuli, and the equipment used to present those stimuli may have substantial effects on the data that result (see Newman et al., 1987; Smith & Benning, 2021, e.g., in psychopathy and sensation seeking, respectively). To the extent that tasks and stimuli are openly available, researchers can reference them in their registrations. Likewise, the responses that will be collected, whether a single response or multiple responses will be allowed, and the devices collecting those responses (e.g., button presses, psychophysiological equipment) determine what data will be available for analysis. Finally, experiments may simulate interactions among people through either real people performing a task together or computerized simulacra of human relationships. These interactions may entail payoff matrices, preprogrammed strategies, or changes in the affordances of the experiment based on a participant's behavior (Baggio & Benning, 2022), some of which may require debriefing. The more of these parameters that are preregistered, the more transparent the experimental design and the more transparently tests' severity of the interpersonal processes at play can be evaluated.

Coregistering experiments can reflect what experimenters learn about tasks as they conduct them. Certain stimuli may not behave as expected and require replacement through a study, or unexpected carryover effects within or between tasks may have undesired effects on responses during the experiment. Additional responses of interest (e.g., reaction time as well as accuracy, sequences of responses) might become interesting based on newly published literature, or the procedure for collecting of a particular response may need adjustment (e.g., additional tape might be needed around ear sensors to collect the postauricular reflex when

participants must wear masks during a pandemic). Participants in the study may behave differently from pilot participants, or additional manipulations might be required to make the behavior of a computerized participant in a task believable as assessed during a debriefing procedure. In any of these cases, alterations to an existing protocol may be coregistered to update a preregistration in accordance with the reality of conducting experimental psychopathology research.

Postregistering existing experimental data requires selecting which types of trials and measures are selected from the corpus of data while acknowledging which previous analyses have been conducted, particularly those that might bias the current study's selections. Compared with nonexperimental personality disorder research data sets, which often contain a large number of measures and can therefore be used as a rich source of information for testing many hypotheses not fully related to the original study, measures within experimental data sets typically are tailored to answer the original research question(s). Consequently, postregistrations will more than likely be focused on secondary hypotheses that arose during the initial project. Thus, researchers must take care to adequately justify further analyses of such data sets, especially when only a subset of the data is targeted.

Intervention Studies

Rows 3 and 4 of Table 1 also provide important considerations for intervention study registrations. Preregistrations of intervention studies in personality disorders would entail the nature, frequency, and follow-up of the interventions to be provided. Waitlist controls are likely to overestimate the treatment effect size (Furukawa et al., 2014) and are ethically questionable when empirically supported treatments for a number of personality disorders exist (Keefe et al., 2021, for borderline personality disorder). Thus, the comparison treatment arm(s) should be preregistered along with the method of assigning participants to treatment arms and the levels of masking of people involved in the study. To the extent an intervention has a readily accessible manual (or even better, an open access manual), preregistering the use of that manual would be sufficient along with the fidelity checks to ensure clinicians are providing the intervention correctly (Stain et al., 2016). Otherwise, preregistering the portions of the intervention subject to fidelity checks highlights the critical aspects of the intervention to get right (Diamond & Hersh, 2020, for adapting transference-based interventions for borderline personality disorder to treat narcissistic personality disorder). The allegiances of treating clinicians and the researchers would also benefit from preregistration to help broader audiences judge the positionality of those involved in delivering the interventions. Finally, the efforts that researchers would make to retain participants in the study (e.g., number and timing of appointment reminders, attempts to contact those who do not attend a particular session, delivery of missed content in the next session) would influence the similarity of a study to community-based client retention efforts and thus would bear preregistration.

Coregistrations can indicate protocol developments that occur during the study to maintain the feasibility of or fidelity to the intervention that was assumed in a preregistration. Changes driven by ethical considerations may be more common here compared with other types of coregistrations. For example, to retain participants who might experience more distress during an intervention

than was expected, additional procedures may need to be implemented and registered to reduce participant distress according to the dictates of a data and safety monitoring board. Should therapists have trouble maintaining fidelity to an intervention, the additional steps taken to train them can also be coregistered, as can any adjustments to the specific techniques used to deliver the content of the intervention. Because data collection is often slower in intervention studies than other study designs, relevant qualitative data collected during the earliest stages of data collection can be a valuable source of information for improving procedural protocols and analytic plans. Coreregistrations provide a transparent, organized mechanism by which researchers can fully explain the need for and value of these changes.

In addition to typical secondary data analyses of change in personality disorder symptomatology and functioning, postregistrations of interventions might take advantage of the rich video and audio data that could be collected during interventions with participant consent. Such postregistrations could examine the interpersonal dynamics that occur during intervention sessions (Sadler et al., 2015, in narcissism), collating how particular dynamic patterns or specific occurrences that might not have been expected are associated with therapeutic change and maintenance of gains. This rich source of qualitative data could consequently help justify a future preregistration that seeks to examine and test these observed processes more explicitly, creating a productive cycle of research that could sustain itself for several projects. Thus, proper utilization of the registration continuum across studies not only protects against the development of degenerate research programs marked by messy theories, it also actively facilitates the growth of strong research programs by providing clear, parsimonious paths forward in successive studies.

Data Reduction and Cleaning Protocols

In any study, any process of reducing raw data into observations for statistical analysis should be registered, preferably with the code for these transformations; these steps are given in Row 5 of Table 1. These may entail reducing psychophysiological activity (De Pascalis et al., 2019, in psychopathy), generating sequences of behavior (Testori et al., 2019, in psychopathy), transcribing speech or interview samples (AlaviHejazi et al., 2017, in histrionic personality disorder), summarizing vocal characteristics (Low et al., 2020, across psychopathologies), coding facial expressions or reactions (Gadea et al., 2015, in dependent personality), or schemes for analyzing qualitative data (Vanderveren et al., 2021, in borderline and antisocial personality disorders). For each of these, citing preexisting guidelines may be sufficient to register these procedures transparently. However, if field-wide guidelines do not exist, a lab may have uploaded standard operating procedures into a repository that may be inspected without incorporating them into a registration. If none of these are available, researchers should register the precise steps that will be undertaken to reduce a study's data, preferably with citations that justify these steps according to the theory behind the data reduction processes at play.

Considerations about how observations should be defined as outliers or transformed after data are reduced should be registered. These must proceed from an understanding of the data generating processes underlying each variable rather than convenient rules of

thumb. For example, normal-range personality disorder trait scores are usually normally distributed, whereas scales assessing personality pathology are often positively skewed following a log-normal process (Kendler et al., 2017). Rather than censoring variable observations at a particular level of extremity, transformations of the variable are likely to accord with a theory. Researchers may find situations in which observations are not on the same scale across participants (e.g., mean reflex magnitude or overall force used to press a button) and in which they believe that between-person variability in scaling is noise rather than signal for the research question at hand. In such situations, researchers can register a transformation (e.g., within-subject z scoring, percent of maximum response) that places all participants' scores on a common metric. Multivariate outliers may be detected with the Mahalanobis distance statistic or its robust versions (Leys et al., 2018). In any case, removing observations as outliers should be reserved for situations in which a datum does not belong to a reasonable data generating process. For instance, values that are coded as -999 to reflect their missingness that are not picked up as missing in a statistical program can be removed validly, as could data that result from double-hitting a key on items with a single-digit response scale. Likewise, suspected patterns of invalid response can be registered (Sharpe et al., 2021). Conversely, data from one assessor or therapist in a clinical trial may not meet registered reliability levels and need to be removed from the final analysis, possibly with refreshment from another provider (Deng et al., 2013). If these issues are not uncovered during preregistration or pilot testing, they can be coregistered or postregistered to maintain data integrity.

The final step of data preparation to register regards how researchers prefer to deal with missing data and aggregating observations for analysis, as given in Row 6 of Table 1. In the case of nearly complete data, researchers may be comfortable using only complete cases, believing that having so few missing data points would be unlikely to bias analyses. Data sets with more extensive missingness might require imputation. In smaller longitudinal samples with non-normal data that are likely to be missing at random, researchers may prefer to register techniques like full-information maximum likelihood imputation (Shin et al., 2017). Larger samples with more normal data that are not missing at random might impel researchers to prefer multiple imputation methods (Sikov, 2018). Each of these methods has parameters that influence the quality of imputations and deserve further registration. Chief among these is the level at which imputations will be performed. Network analyses likely require imputation at the symptom level; latent variable imputations may proceed at the item or scale level.

Statistical Models

Personality disorder researchers have a panoply of possible statistical models they can use to analyze their data, ranging in complexity from a one-sample t test to a multilevel longitudinal model. Registering the intended data analytic framework allows researchers to consider the assumptions behind their models and how to ensure data meet those assumptions to avoid drawing erroneous conclusions, which are sketched in Row 6 of Table 1. Models can be sensitive to the particulars of measures used. For instance, using structural summary variables instead of correlations among

interpersonal octants revealed homogeneous socially avoidant/nonassertive avoidant personality disorder profiles but heterogeneous domineering and exploitable obsessive-compulsive personality disorder profiles (Solomonov et al., 2020). Models should be registered contemporaneously with the number of observations to aid in power or sensitivity analyses. Simpler models like analyses of variance may have analytical solutions to power calculations, but multilevel models often require simulations to numerically approximate those calculations for complex interpersonal designs (Lane & Hennes, 2018). The more complex the models, the more necessary it will be for researchers to register the code they intend to use for their analyses to ensure that those analyses can be replicated when data are obtained (Obels et al., 2020). If needed, researchers can generate random values to populate each variable in the model to generate initial analytic code. That procedure ensures the proposed models can be evaluated in the researcher's chosen software.

Personality disorder studies need not test hypotheses about specific parameters; rather, they may look to assess the plausibility of entire models relative to each other or to a default model. Registration gives researchers the opportunity to describe the theoretical rationales behind the paths they choose to estimate or effects they will include in a model. It also permits specifying theoretical or empirical rationales for particular estimators to use and other appropriate technical details of model estimation. Researchers can register the fit statistics they will use to compare models, including which statistic(s) will be primary in interpretations should the conclusions be mixed across statistics. Cutoffs for fit statistics need not be static; rather, they may depend on the structure of the data (McNeish & Wolf, 2021), and registrations can articulate these dependencies.

Registered Flexibility to Plan for Contingencies in Research

A common misperception of registrations is that they are inflexible documents, constraining studies to a narrow path no matter what issues arise in their conduct (Brainerd & Reyna, 2018). However, in addition to the options of coregistration and postregistration to update preregistrations, researchers can take advantage of *registered flexibility* to specify decision trees and flowcharts to adapt to research contingencies (Benning et al., 2019). Registered flexibility gives research activities to proceed according to various conditions that might arise without requiring inspection of the data before the study occurs. For instance, researchers can specify how few participants in groups with small numbers (e.g., 10 or fewer) would justify collapsing those groups into an "other" category or the critical value of intercorrelations among predictors that would justify dropping all but the most theoretically relevant predictor (e.g., $r > |.80|$). They could also specify the characteristics of a distribution that would entail particular data transformations (e.g., $|\text{skewness}|$ and $\text{kurtosis} > 2$) or the model fit statistics that would justify using factor scores from a measure instead of total scores. Figure 2 provides an example flowchart that registers a pathway with citations for data cleaning and factor analysis before primary analyses are conducted.

Registered flexibility provides principled control of error while studies progress. For instance, sequential analyses allow researchers to examine their data at prespecified intervals in recruitment or a study's procedures, permitting efficient use of scarce participants and limited resources when the interim analyses are masked

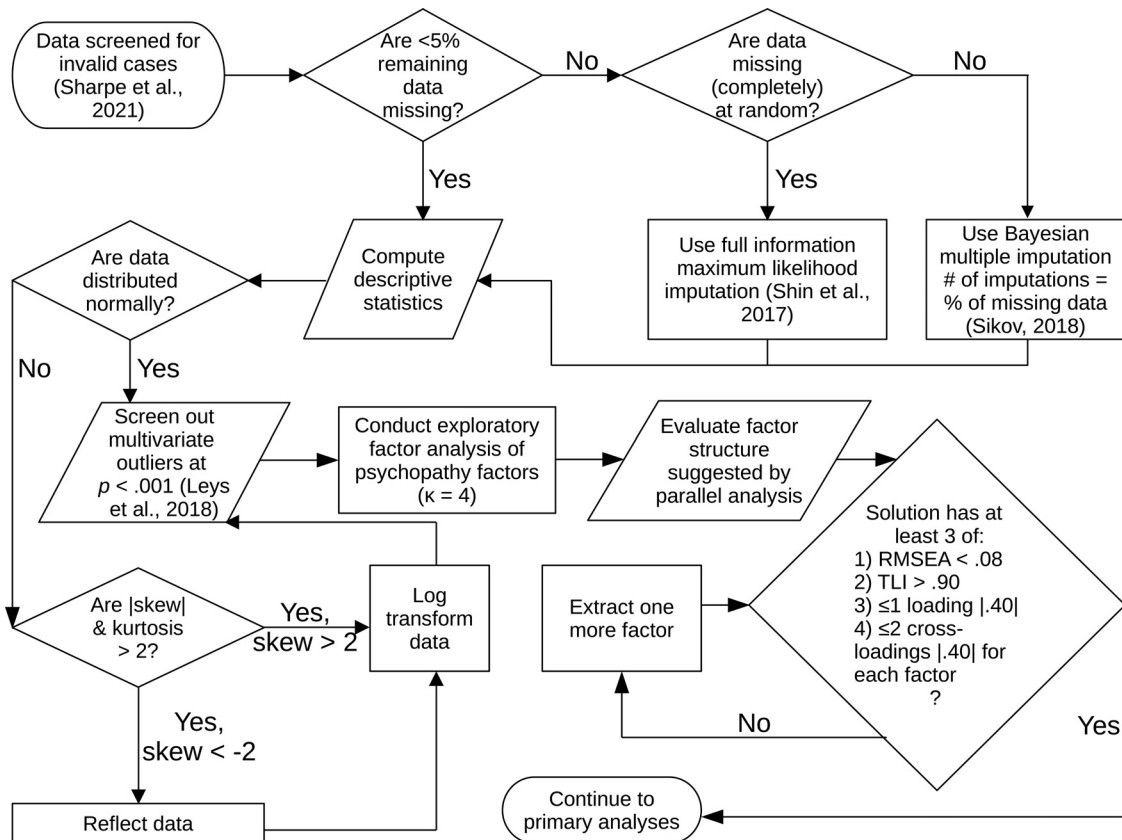
against expectancies (Else et al., 2021). Such analyses make researchers pay a p value penalty at each interval for the flexibility to make ongoing decisions about the study. Likewise, researchers can inspect accruing data and use predefined decision trees about when to retrain assessors or therapists, refresh a sample to account for participant dropout, or reassign participants to another treatment arm should one demonstrate inferiority to another. In this way, researchers make consistent decisions that would generalize across studies independent of the peculiarities of any specific data set.

However, even the most creative registered flexibility may not account for all important aspects of research design. Unexpected contingencies may arise, the broader literature may uncover flaws uncovered in proposed measures or statistical models, and reviewers may discover shortcomings in the registrations reviewers use. In these cases, researchers can use sensitivity analyses (Thabane et al., 2013) to document the range of analytical conditions in which their hypotheses hold. Researchers are also free to explore their data to investigate intriguing possibilities they had not considered when devising a study. Exploratory analyses simply must be indicated as such in the results section of a article, preferably with controls for false discovery rates used. This process ensures readers are aware of the distinction between registered and exploratory work. They can make informed assessments about the contributions of a set of exploratory analyses, including which deserve registered follow up. With large enough samples, data sets can be divided into exploratory (training) and registered (test) sets, allowing a single report to describe both kinds of analyses in a planned fashion.

Exemplar Registrations in Personality Disorder Research

Table 2 overviews exemplar registrations spanning topics, methods, and finished products. Overall, pre-or postregistrations are more common than coregistrations, and coregistrations may fail to detail that data collection is underway (e.g., Study 11, which should have stated that "Data collection has been ongoing since January 2019 and is anticipated to end on October 2019; we have not inspected the data collected thus far."). Study 8 demonstrates that clinical trial registrations typically have many fewer details than other registrations (especially concerning how data will be transformed and analyzed) in contrast with the templates used in Studies 5 and 9. Studies 2 and 3 reflect how registration standards are evolving quickly, with Study 3 providing more detail about factor analytic strategies than Study 2. Study 10 shows how pre-registered basic task analyses and postregistered correlations with task scores can be combined in a single article. In two examples of registered flexibility, Study 5 describes how models derived in an exploratory sample will be used to test those models in a separate test sample, and Study 9 provides an example of a recontact plan that ended up not needing to be used in the final study.

Many studies in Table 2 show how registrations can be updated themselves or between registration and final product. Study 4 has an impressively faithful translation of registration to thesis, as only the edge color for positive associations shifted from green to blue, respectively. Study 7's updated registration demonstrates how to document transparently any changes made after initial data inspections. Study 12 provides good text in the article's method describing an exploratory skin conductance response analysis that

Figure 2*Example of Registered Flexibility Flowchart to Handle Data Cleaning and Model Selection Before Analyses*

Note. This diagram represents a schematic version of the data analytic portion of the preregistration at <https://osf.io/mctye> regarding which factor structure of psychopathy to use in subsequent analyses. In this flowchart, ovals represent start and end points of a decision process, diamonds represent decision points, parallelograms represent the handoff of data to another process, and rectangles represent the outcomes of a decision or data processing step. Figure by Stephen D. Benning; available at <https://doi.org/10.6084/m9.figshare.17912405.v3> under a CC-BY4.0 license.

complements the preregistered skin conductance level analysis. Study 2 highlights that authors need to be careful about disclosing deviations from the registration plan, as the analytic framework moved from a confirmatory to exploratory factor analytic approach without revealing that fact in the article. Study 6's article describes nicely in footnotes the specific places in which the analyses deviated from the preexisting plan due to the authors' decisions, and Study 1's article highlights which analyses in the article deviated from those in the registration due to reviewer requests.

Challenges in Evaluating and Implementing Registrations

Registration holds promise in evaluating theoretical tests' severity and in assisting researchers in more thoroughly describing their studies (Toth et al., 2021), but simply registering a study does not guarantee sound science, and evaluating studies according to their registrations is challenging. More than one-third of articles do not report sufficient detail in the registration to allow evaluating whether the final study report followed the registration (Heirene et al., 2021). Thus, reviewers may have substantial difficulties

assessing study registrations, particularly if version-controlled updates to a registration require inspections of multiple drafts to examine how a study has changed over time. The personality disorder field could adopt either of two approaches to allow automated similarity checking of registrations and manuscripts with tools like iThenticate or Turnitin. The similarity score of the registration and relevant article sections could be reported in the journal as a rough quantitative measure of registration success, though this idea has not been tested formally. A "submit your way" article submission system would let researchers submit drafts as close in structure to their registrations as possible to make generating such similarity scores easier. The field could also standardize on a structured registration format (Bakker et al., 2020) that would generalize across article formats in journals, which would then be promoted in major repositories in which preprints and registrations are housed. Journals may also use a review specialist to verify registrations, opening up a new nontraditional academic career.

To implement study registration more easily, researchers can have their trainees create accounts on the Open Science Framework or Github.com (a website that provides file timestamping

Table 2
Exemplars of Registered Studies in Personality Disorder Research

Title	Authors	Study type	Registration type	Registration format	Registration link	Manuscript or article link	Registration deviations detailed?
Measurement studies							
1. Investigating the higher order structure of the Comprehensive Assessment of Traits relevant to Personality Disorders	Emery, Simms, and Ringwald	Measurement validation	Post	OSF preregistration	https://osf.io/kae9h	https://psyarxiv.com/kuefm/	Yes (reviewer requests)
2. Transdiagnostic hostility and the structure of the concept in terms of cognition, affect and behavior	van Teffelen	Higher order construct structure confirmation	Pre	Preregistration in social psychology	https://osf.io/gpju6	https://doi.org/10.1371/journal.pone.0239631	No (bass-ackwards analyses, outlier criteria)
3. Unfolding psychopathy	Crowe, Miller, and Lynam	Higher order construct structure exploration	Post	OSF preregistration	https://osf.io/6crjk	N/A	N/A
Concurrent relationship studies							
4. The differential association of the individual borderline personality disorder diagnostic criteria with well-being, past suicide attempts and comorbidities	Cloos, Fried, and Krause-Utz	Network analysis registering existing data	Co/post	AsPredicted.org template	https://osf.io/9q43h	https://hdl.handle.net/1887/77853	None
5. Exploring the incremental predictive validity of personality disorder nuances	Müller and Zimmermann	Machine learning study of preexisting clinical data	Post	Free response: Following van den Akker et al. (2021) template	https://osf.io/8evm9	N/A	N/A
6. Psychopathy and boldness: Replicating Gatner et al. (2016)	Sharpe Lynam, and Miller	Registered replication of previous null results	Pre	Free response	https://osf.io/jng6s	https://doi.org/10.1037/per0000531	Yes (variable transforms, analytic step separation)
Longitudinal studies							
7. Exploring a cascade model of urgency: Momentary dynamics of stress, affect, and impulsivity and their correlates	Sharpe and Wright	Ecological momentary assessment with prior analytic code and updated registration	Post	OSF preregistration	https://osf.io/nam9	Based on https://doi.org/10.1521/pedi.2020.34.465	Yes (interim deviations for scaling)
8. Effects of a 6-week mechanism based psychotherapy program on biobehavioral mechanisms of reactive aggressive behavior in patients with a borderline personality disorder	Herpertz	Intervention with registered primary and secondary outcomes over a 6-month interval	Pre	Clinical trial registration	https://www.drks.de/drks_web/navigate.do?navigationId=TRIAL_ID=DRKS00009445	https://doi.org/10.1192/bjo.2020.131 https://www.mdpi.com/2076-3425/11/12/1627/html	Yes (OAS-M items)/no (log transform, covariate adjustment) No (fMRI parameters/stats not registered)
9. Who am I? Constructing an identity following EUPD diagnosis and hospitalization	Davison	Qualitative study with recontact plan ensuring thematic exhaustion	Pre	Preregistration and preanalysis plans for qualitative inference template/forms	https://osf.io/zvfcv	https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.847999	None

(table continues)

Table 2 (continued)

Title	Authors	Study type	Registration type	Registration format	Registration link	Manuscript or article link	Registration deviations detailed?
10. Assessment of Physical Risk Taking	Smith and Benning	Experiment development	Pre: Basic task-level analyses	Free response: Thesis proposal	https://osf.io/bwuxn	https://doi.org/10.1371/journal.pone.0258826	None
	Smith and Benning	Task score correlations with externalizing	Post: Construct validity with externalizing	Free response: Document upload	https://osf.io/n62tf/		
11. Dark Tetrad responses to moral dilemmas	Wrenn and Benning	Vignettes manipulating responsibility and emotion	Co (but not explicit in registration)	Free response: Thesis proposal	https://osf.io/s37fw/	https://digitalscholarship.unlv.edu/thesesdissertations/3975/	Yes (redefined comparison families)
12. The effect of emotion regulation and impulsivity on reversal learning	Paret and Bublatzky	Experiment including null PD findings	Pre	OSF preregistration challenge	https://osf.io/bxvqgm	https://doi.org/10.1016/j.brat.2020.103636	Yes (exploratory SCR)

Note. EUPD = emotionally unstable personality disorder; PD = personality disorder; OSF = Open Science Framework; OAS-M = Overt Aggression Scale-Modified; fMRI = functional magnetic resonance imaging; SCR = skin conductance response; N/A = not applicable.

and version control). Trainees can then upload their milestone proposals to start registering their own studies. They can also participate in drafting registrations higher in the disclosure axis. Registering a lab's standard operating procedures will speed this process, and gaining experience in a field will give researchers more registered flexibility. These efforts will prevent research programs from degenerating and speed research that reduces human suffering while strengthening the theories and science behind personality disorders.

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