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**Investigating Stable and Dynamic Aspects of Psychological Needs Using  
Generalisability Theory**

A thesis  
submitted in partial fulfilment  
of the requirements for the degree  
of  
*Master of Social Science in Psychology*  
at  
**The University of Waikato**  
by  
**Scott Dean Drabble**



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### Abstract

Satisfaction of psychological needs has been linked to human flourishing and improved wellbeing and basic psychological needs are central to self-determination theory (SDT) and include autonomy, relatedness, and competence. Accurate distinction between stable and dynamic aspects of these psychological needs is necessary for the development and assessment of interventions aiming to maximize satisfaction of these needs. The widely used Basic Psychological Needs Satisfaction scale (BPNS) was developed to measure the degree to which people feel satisfaction of the three basic psychological needs but its ability to reflect stable and dynamic aspects of needs and generalisability of assessment scores were not thoroughly examined by implementing an appropriate methodology.

Generalisability theory (G-theory) has been recommended as an appropriate statistical method to evaluate the state-trait distinction while providing reliability analysis and accurate evaluation of sources of measure error. G-theory was implemented to distinguish between state and trait aspects of psychological needs and to assess the reliability of the BPNS. A longitudinal person by item by occasion observational design was applied to an adequate sample of 116 participants who completed the 21- item BPNS at three time points with a one-month interval between assessments. The total BPNS showed acceptable reliability and generalisability of scores in assessing the need satisfaction trait across sample population and occasions ( $G = 0.75-0.88$ ) while individual subscales of the BPNS appeared less reliable due to dynamic nature of needs reflected by these subscales. A brief subscale to measure the most dynamic needs as a state was developed using items reflecting dynamic aspects of psychological need. The overall good reliability of the total BPNS and dynamic properties of the individual subscales, suggest the overarching latent trait of neediness that varies across individuals while specific needs are state like and therefore can shift from one aspect to another depending on circumstances of individual's life.

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## Chapter 1 Self Determination Theory

Self-determination theory (SDT) (Deci, 1985; Deci & Ryan, 1991, 2000)

differentiates the contents of goals and the regulatory processes from where these outcomes are pursued. Where research once focused on goal directed behaviour, SDT has suggested that without including the needs that underpin goals, then a full understanding of psychological development, wellbeing, and goal directed behaviour cannot be achieved (Deci & Ryan, 2000). Further, SDT includes the concept of innate psychological needs from which the content of goals and the regulatory processes are integrated while making predictions for different contents and processes. The innate psychological needs are determined as being basic psychological needs and include the need for Autonomy, Relatedness, and Competence (ARC). These needs are suggested as being universally held and central to human psychological flourishing (Chen et al., 2015; Deci & Ryan, 2000)

The need for autonomy refers to perceived freedom related to an individual's behaviours and perceived power to make independent decisions (Deci & Ryan, 2000; Van den Broeck et al., 2008; Van den Broeck et al., 2010). While expansion on the autonomy definition includes the idea that individual needs serve the purpose of alignment of self determined goals (Schiemann et al., 2018). The psychological need of relatedness is defined as being connected to others and feeling a desire for this need to be maintained (Martela & Riecki, 2018). This includes a reciprocal relationship between individuals where love and caring are given and received. Finally, the third psychological need of competence is described as being a desire within individuals to acquire goals or outcomes by succeeding at various challenges and in a way that allows that individual to be the master of their environment (Van den Broeck et al., 2010).

Specifically, SDT proposes that the satisfaction of these needs is suggested to improve psychological health and aid in life satisfaction (Deci & Ryan, 2000). Indeed

extensive research has shown that basic psychological needs play extremely important roles in development, adjustment and cultural wellness (Vansteenkiste et al., 2020). Individuals that prevent or obstruct the fulfilment of basic psychological needs are adversely affected in areas such as performance, motivation, and well-being (Deci & Ryan, 2000). SDT postulates that needs of ARC will produce healthy development and functioning and the enjoyment of participation in activities while promoting self-regulation of autonomy of behaviours if these needs are fulfilled at regular intervals (Deci, 1985; Deci & Ryan, 1991, 2000).

Furthermore, Gagne (2003) investigates the role that autonomy support and autonomy orientation plays in the engagement of prosocial behaviours that are intertwined with SDT where the needs of ARC are essential for our understanding of the why and what of goal pursuits (Deci & Ryan, 2000). With that being said, the focus and function of SDT are to capture an understanding of human motivation through the innate needs that the ARC both provides and measures. Measurement and research into psychological needs and the motivational processes that are attached to these needs, allows researchers to answer why individuals and collectives act or portray the behaviours they do in any given situation.

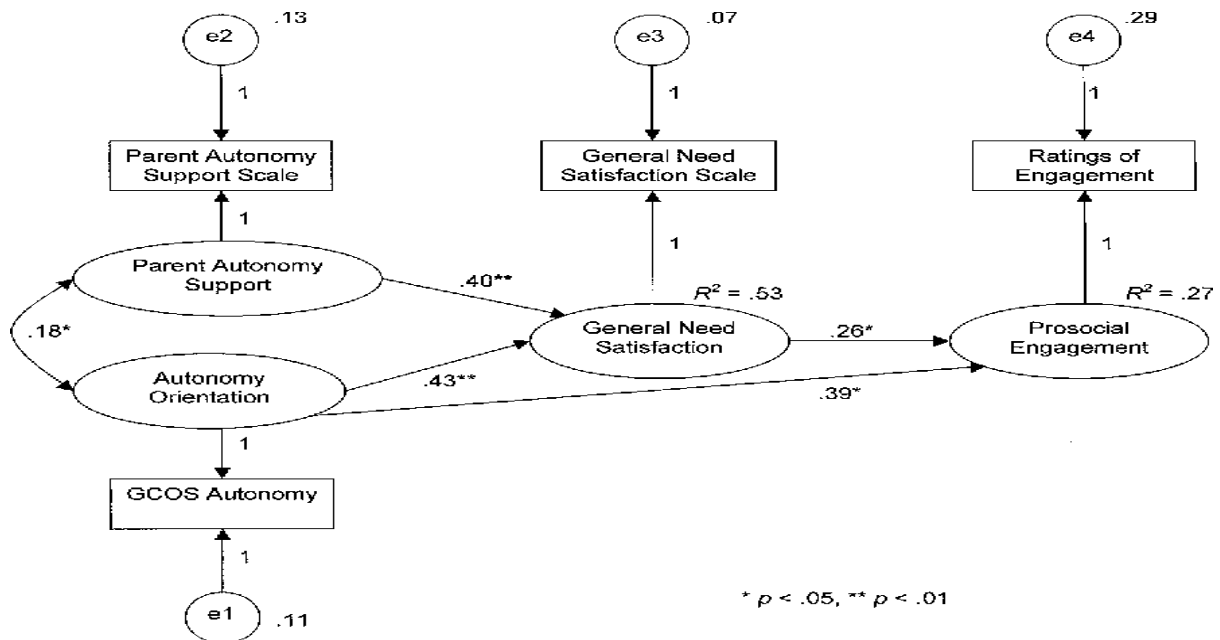
Contemporary theories such as SDT and the six mini theories of SDT discussed below, have the assumption that motivational behaviours exist to produce individual goals that will lead to desired outcomes (Deci & Ryan, 2000). These theories build on original behavioural studies such as purposive behaviour with Tolman's view of behaviour as molar (Tolman, 1932) and topological psychology where the relationship between attraction and repulsions in one's life is the subject of interest (Lewin, 1936). Such theories have steered motivational researchers towards three key areas that require further investigation. These include; the exploration of the psychological value that individuals attribute as being innate to the goals of which they wish to achieve (Ballard et al., 2018; Kasser & Ryan, 1996), contributing factors that lead to people moving towards goals, and peoples beliefs about goal

attainment (Deci & Ryan, 2000). These three areas directly relate to the basic psychological needs of ARC in so much that they all have a focus on goals where the underlying motivational aspects allow some explanation of need satisfaction.

The suggestion from SDT is that if these three psychological needs are met, an individual regardless of their culture or cultural background will maintain healthy psychological development and wellbeing. Contexts that enhance the satisfaction of the three basic psychological needs will increase enjoyment and aid in the beneficial improvement of autonomous behavioural self-regulation (Bland & Altman, 1997; Gagné, 2003). Furthermore, the satisfaction of these basic psychological needs is directly linked to the causation of pro-social behaviour which can be predicted by using a model of autonomy orientation and autonomy support (Gagné, 2003). Figure 1 illustrates the satisfaction of ARC and its link to causation of prosocial behaviour. This example from Gagne (2003) was investigated through parental autonomy support. Findings showed that autonomous orientation support impacted need satisfaction which in turn positively impacted engagement in prosocial activities (Gagné, 2003).

**Figure 1**

Results of the Final Path Analytic Model Adopted from the Role of Autonomy Support and Autonomy Orientation in Prosocial Behaviour Engagement



*Note.* From “The Role of Autonomy Support and Autonomy Orientation in Prosocial Behaviour Engagement”  
 M Gagné, 2003, *Motivation and Emotion*, 27(3), 199-223. (<https://doi.org/10.1023/A:1025007614869>).  
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Furthermore, Gagne (2003) suggests that both environmental forces and individual differences influence motivation either intrinsically or extrinsically which will affect engagement in pro-social behaviours. This is a complex relationship and as such is why interactions are important to evaluate if measuring these constructs. Autonomy orientation refers to people’s early social interactions where they develop in a manner akin to autonomous self-regulation or where they can be guided more by their experiences of the environment. Being guided equates to being regulated or controlled without the individual’s explicit recognition of this phenomena and as such is classified as autonomy orientation causality. It is the differences in causality orientation that can determine differences in an

individual's basic psychological needs being met (Gagné, 2003). For example, research has discovered that people in a workplace environment that have a high autonomy orientation, that can self-regulate individually without the need of guidance from environmental factors, enjoyed better need satisfaction at work. This in turn improved performance and individual well-being (Baard et al., 2004). Autonomy support on the other hand refers to personal choice and encouragement for personal initiative while supporting competence (Gagné, 2003). If these aspects are satisfied then the suggestion is that autonomous motivation (intrinsic motivation) is achieved and this can be contrasted to controlled motivation (extrinsic motivation) which is achieved through the opposite of these aspects being satisfied (Gagné, 2003). The suggestion here is that the interactions we have with other people can determine our basic need satisfaction of ARC.

Moreover, one rule does not fit all when discussing individual motivation. While there is an overall level of motivation that individuals possess, this level is retained to different degrees within people (Lyndon et al., 2019). In this study empirical evidence was provided by using G-theory. The level of motivation that is inherent in individuals is said to be stable across a long period of time while some individuals display generally more or less motivation than others. The same can also be said of the type of motivation or orientation where people have different types of motivation depending on needs (Ryan & Deci, 2000). Motivation can be seen to be a very dynamic construct illustrated by individuals' tendencies to move between intrinsic and extrinsic motivation depending on life circumstances. Thus, motivation shifts between intrinsic and extrinsic with the overall level of motivation remaining relatively stable.

SDT discusses how important it is for individuals to have need satisfaction take place. However, an individual can also experience frustration from a lack of basic need satisfaction and can display adverse effects. For example, previous research suggested that low

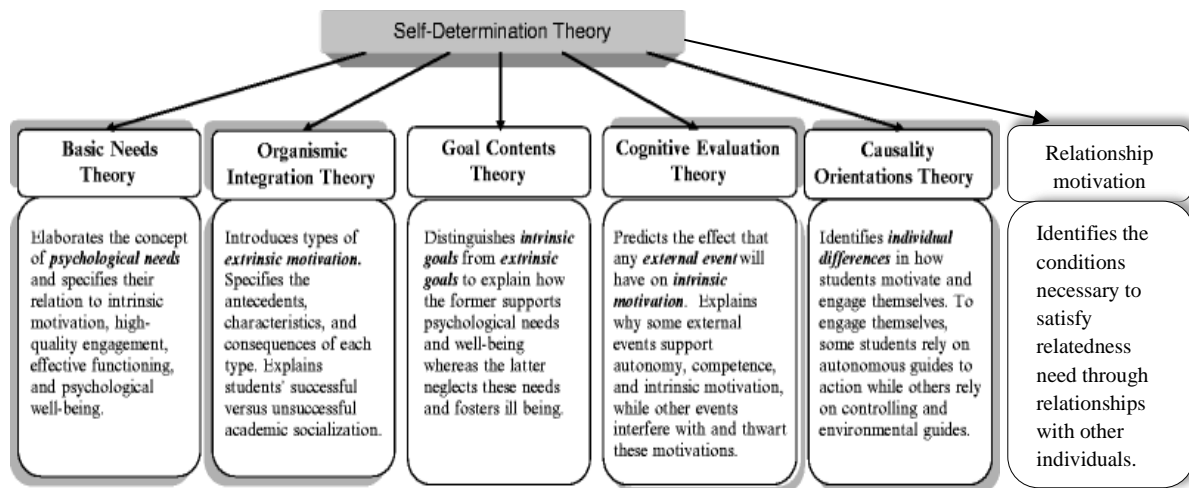
psychological need satisfaction and therefore the frustration of needs or unsatisfied needs relates directly to poor sleep quality, less sleep quantity, and increased daytime dysfunction (Campbell et al., 2015). Fundamentally importance must be given to aiding individuals in the satisfaction of their basic psychological needs of ARC.

SDT proposes six mini theories with each being developed to explain a set of motivationally based phenomena (Deci & Ryan, 2000). Figure 2 illustrates the six mini theories and the motivational phenomena each was developed to explain. Each theory has been developed to examine one facet of personality functioning or motivation. These include Cognitive Evaluation Theory (CET), Organismic Integration Theory (OIT), Causality Orientations Theory (COT), Basic Psychological Needs Theory (BPNT), Goal Contents Theory (GCT), and Relationships Motivation Theory (RMT), (Deci & Ryan, 2000; Ryan & Deci, 2000a). Firstly, CET has a focus on intrinsic motivation or behaving in one's own interests and investigates the effect of how different social contexts effect intrinsic motivation. OIT addresses extrinsic motivation as being behaviour that is instrumental where ideas such as external regulation, introjection, identification, and integration are key themes. COT is concerned with the orientation of people towards certain environments and the regulation of behaviours in different ways regarding individual differences. BPNT is conceptualised by evolved psychological needs and how these needs affect well-being. The psychological needs of ARC are determinants for the satisfaction or frustration of these needs. BPNT also includes the criteria which must be met for a need candidate to be included in the three already established basic psychological needs (Vansteenkiste et al., 2020). CGT highlights the distinctions between intrinsic and extrinsic goals and how these might impact ideas such as motivation and wellbeing. And finally, RMT has fundamental ideas which relate to relatedness in so much that relationships foster the conditions necessary for the

satisfaction of the basic psychological need of relatedness and therefore induces wellbeing (Deci & Ryan, 2000; Ryan & Deci, 2000a).

**Figure 2**

Six Mini Theories of Self Determination Theory and the Motivational Phenomena each was Developed to Explain (Adapted)



Note. From (Christenson et al., 2012) “Handbook of Research on Student Engagement”, (DOI 10.1007/978-1-4614-2018-7\_2), Copyright 2012 Springer Science+Business Media, LLC

SDT provides the structure of a meta-theory for motivation and personality with a viewpoint that people are active organisms. The conditions that support the satisfaction of the basic psychological needs in which SDT suggests are common in all people are said to be essential in enhancing wellbeing. The opposite can also be suggested with frustration of wellbeing if these needs are not satisfied. As SDT suggests, individuals strive for psychological growth and integration, which we achieve by inherently have goals of learning, connecting with others, and mastery of tasks and challenges (Ryan & Deci, 2020). These goals, if met allow us to satisfy our basic psychological needs.

**Psychological Needs and Intrinsic Motivation in SDT**

The factors that either facilitate or impede intrinsic motivation from a psychological needs perspective can be found within the broad framework that is SDT (Ryan & Deci,

2020). Definitions and research on intrinsic and extrinsic motivation as a field of study started to emerge at the start of the 21<sup>st</sup> Century (twenty years ago at the time of writing). Since this time, extensive exploration of these ideas has been achieved with a particular reference to motivation and SDT. Intrinsic motivation can be defined as the inherent satisfaction that one achieves through the completion of a task rather than the attainment of a separable outcome such as an external reward or external product (Oudeyer & Kaplan, 2009). Other additions to this definition include the ideas that intrinsic motivation involves active engagement that provides the individual with interest in a task which necessitates the antecedent conditions that allow personal growth (Deci & Ryan, 2000). Furthermore, individuals will have an increased or decreased interest in a task dependant on the degree to which they experience basic need satisfaction while engaging in the task (Deci & Ryan, 2000). Again, this forms one of the basic underlying ideas of SDT and need satisfaction. The scope of the definitions of what intrinsic motivation is in regards to psychological needs illustrates that the needs of autonomy and competence require satisfaction for these intrinsically motivated needs in one's life and to promote personal growth (Deci & Ryan, 2000; Ryan & Hawley, 2016).

The need for autonomy to be satisfied as being essential to intrinsic motivation is illustrated through numerous research examples within quite contrasting areas. For example, negative feedback and threats of punishment (Deci & Cascio, 1972) is a good illustration. Specifically, the effects on intrinsic motivation through adult supervision of children (Lepper & Greene, 1975) highlight the effects of diminishing autonomy from an individual perspective which can result in the undermining of intrinsic motivation. The opposite can also be said of extending autonomy, best illustrated by research such as; perceived job autonomy or the extent to which a job allows freedom (Dysvik & Kuvaas, 2011), and the implementation of autonomy skills training to foster enhanced intrinsic motivation (Fukuda et

al., 2011). For example, autonomy can be extended by implementing an autonomy supportive work design or work environments. However, a model of one size fits all is not appropriate as individuals vary in their needs, meaning that a tailored autonomy supportive work design would need to be investigated and individual levels of intrinsic motivation gauged (Dysvik & Kuvaas, 2011). Further interpretation discusses how the use of autonomy supportive behaviours which offer an individual meaningful choice, minimal environmental pressure, and shared responsibility in decision making, leads to improved need satisfaction and increased motivation of self determined autonomy (Sullivan, 2019). These examples suggest how enhancing autonomy could enhance intrinsic motivation.

Increased perception of being competent in a task or activity will produce increased intrinsic motivation within that task or activity (Deci, 1985; Painter, 2011). The idea that competence can be gauged by an individual from both self-evaluation and from external evaluation such as positive feedback which in turn increases intrinsic motivation (Deci & Ryan, 2000), has been conceptualised through previous investigation and experiments. One such example of this is in motivational feedback research findings which discuss increased satisfaction of athletes' competence and the relationship this has with heightened intrinsic motivation (Fransen et al., 2018). The converse process also reiterates the relationship between competence and intrinsic motivation by displaying the effects of competence frustration and intrinsic motivation. Research conducted by Fang et al (2017) investigated competence frustration and intrinsic motivation with findings suggesting frustration of competence undermines an individual's intrinsic motivation. Here the relationship was described as a u shaped relationship where competence frustration was found to undermine intrinsic motivation in the same activity (Fang et al., 2017). Specifically, the competence frustration from the participants involved in that study from a preceding course was found to positively predict levels of intrinsic motivation in in following courses.

The optimal conditions for intrinsic motivation to be enhanced is when those conditions allow the satisfaction of both autonomy and competence (Deci & Ryan, 2000). It must also be mentioned that SDT suggests that relatedness also plays a part in the process of intrinsic motivation but it needs to be mentioned that this occurs to much less of an extent than autonomy and competence (Deci & Ryan, 2000). Study of the variables which allows the satisfaction of the basic psychological needs is very important and requires reliable and valid assessment tools. These tools need to be able to distinguish between dynamic and enduring aspects of these needs. Otherwise, how is it known if needs are satisfied and the extent to which these needs are satisfied? The limitations of all studies which do not include the distinguishment between dynamic and enduring aspects are suggested as providing a lack of reliability of assessment because nobody bothered to distinguish state and trait.

### **Psychological Needs and Internalisation of Extrinsic Motivation in SDT**

Extrinsic motivation is suggested as being motivation that is occurring for any reason other than inherent satisfaction (Ryan & Deci, 2020). SDT suggests that there are four major subtypes of extrinsic motivation. These are external regulation, introjection, identification, and integration. Firstly, external regulation is said to be behaviour which is controlled and non-autonomous and guided by external rewards or punishments. Introjection is suggested as being partially internalised extrinsic motivation. Or in simpler terms introjection is an unconscious decision of the adoption of others ideas or attitudes (Smith, 2008). Here behavioural regulation takes the form of either a change in ones self-esteem from successes, with failures taking the form of avoidance behaviours. For example, regulation can take the form of self-worth or pride and guilt or shame from avoidance. Introjection is also concerned with the approval for the self and from other individuals and has a focus on relatedness satisfaction. Identification is concerned with the value that is placed on personal importance and of activities that are undertaken, while importance is placed on the regular self

endorsement of goals. For example, children tend to behave like the significant adults that they spend the most time with. The child identifies with that adult and these identifications foster identity and individuality (Adler et al., 1961). Finally, integration is concerned mainly with the synthesis and consistency of identifications while maintaining a level of congruence. For example the APA dictionary of psychology suggests integration as a bringing together of traits, motives, and behavioural patterns to integrate into an organised whole (VandenBos, 2007).

Internalisation of extrinsic motivation has an important impact on satisfaction of psychological needs. However, there is no current literature that differentiates stable and dynamic aspects of psychological needs which could expand understanding of the processes of extrinsic motivation. Further investigation of stable and dynamic aspects of psychological needs could better explain the internalisation process of extrinsic motivation.

### **Needs, Goals, and Regulatory Processes**

SDT is clear in its distinction of the contents of goals and the regulatory processes that are utilised in achieving the desired outcomes concerning goal directed behaviour. SDT maintains specific effects of goal pursuit and attainment about meeting and indeed exceeding the satisfaction of their basic psychological needs (Deci & Ryan, 2000). This approach differs from theories such as the motivational processes that affect learning with a focus on ability development compared with ability demonstration goals research (Dweck, 1986) and approach goals contrasted with avoidance goals (Darnon et al., 2007; Elliot & Harackiewicz, 1996). Furthermore, Deci and Ryan (2000), suggested that a lifelong basic psychological growth function which includes intrinsic motivation and internalization is fundamental to psychological integrity and social cohesion. The areas of intrinsic motivation and internalization are said to be impossible to analyse without including the umbrella term of psychological needs used to interpret and give meaning to those research results (Deci &

Ryan, 2000). SDT proposes that the needs of ARC are fundamental in gaining an understanding of the what and why of goal pursuits (Deci & Ryan, 2000). While the importance of accurate assessment cannot be overlooked.

### **Conclusion**

Investigating why individuals or collectives produce the behaviours they do in specific situations is the key goal of research into psychological needs and the motivational practices that one attaches to these needs. According to SDT, to achieve psychological well-being an individual must satisfy the three innate psychological needs of ARC that give meaning to human motivation. We do not know if these needs are enduring or dynamic and there is an obvious lack of research investigating this important question. To that extent research investigating if these needs are enduring or dynamic require appropriate methodology to be employed.

There is an increasing interest in psychological well-being and the measures that are needed to encapsulate the satisfaction or frustration of the basic psychological needs of ARC. Extensive research extends this thought process to include the idea that if there is support for the three basic psychological needs, then individuals can benefit (Molix & Nichols, 2013) from improved wellbeing. The use of the term need, in SDT is suggested as being a psychological nutrient (Vansteenkiste et al., 2020), this is in contrast to the use of the word need in everyday language which refers to specific desired outcomes. Specifically, a need that results in the satisfaction of any of the three basic psychological needs (i.e. ARC) and is essential to wellbeing is determined to be a psychological nutrient (Vansteenkiste et al., 2020).

SDT builds on previous theories of human motivation and as such proposes new directions of thought and research opportunities. These new opportunities allow us to test new pathways and form a greater understanding of what and why we are motivated to

produce the behaviours that we do as individuals and in collective arenas. The basis of this thought process allows researchers the opportunity to fashion and employ interventions into areas where psychological need satisfaction may not be being employed for individuals so that the frustration of the basic psychological needs is negated. Interventions that are formulated in this way have a goal of allowing an individual to reach a level of flourishing and/or to displace any need substitute that may have been engaged, for example, in specific areas of negative vitality or mental health concerns. SDT allows some predictive models of behavioural and mental health quality to be instilled by differentiating the pursuit and the attainment of individual goals through focusing on the why and the what might be of the motivational factors for an individual (Deci & Ryan, 2000). Furthermore, as empirical studies increase on SDT as there has been strong recent interest in the study of basic psychological needs, many more refinements will extend this theory exponentially (Vansteenkiste et al., 2020). Reliable and valid research is not possible without accurate measurement of these constructs and distinction between state and trait.

## Chapter 2 Measuring Psychological Needs

### Psychological Need Measures

The BPNS is a widely used measure of psychological needs in one's life (Sheldon & Hilpert, 2012). This measure has been developed based on other instruments such as the measure of need satisfaction at work (Deci et al., 2001; Ilardi et al., 1993; Kasser et al., 1992). The BPNS - work domain, was developed to measure the satisfaction of ARC within a working environment but some aspects of this measurement can be applied to everyday life situations. The BPNS has also been used extensively elsewhere, for example, in autonomy support and orientation (Gagné, 2003) and the relationship between psychological need satisfaction and unhealthy weight control behaviours (Thøgersen-Ntoumani et al., 2011).

Validation studies of the BPNS, display support for a three-factor correlated model (Burgueño et al., 2020; Johnston & Finney, 2010), where Cronbach's alpha values range between 0.79 and 0.92 respectively. While the BPNS is the main scale and is used in the current study, other similar scales were developed for specific contexts such as workplace (e.g. BPNS – Work domain (1971; Deci et al., 2001; Ilardi et al., 1993; Kasser et al., 1992) and relationships (e.g. the BPNS – relationship domain (La Guardia et al., 2000). Furthermore, expansions of the basic psychological need satisfaction scale have included frustration scales (e.g., the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) – in general (Campbell et al., 2015; Chen et al., 2015; van der Kaap-Deeder et al., 2015). The frustration included scales also include specific contexts such as physical education, physical exercise, sport, education and work contexts to name a few (Eriksson & Boman, 2018).

The main differences between the BPNS used in the current study and these other scales include a differing number of test items included with a range between 12 to 24 items, while another notable difference is illustrated in the frustration scales which include items

which assess frustration of needs. The BPNSFS guide makes it clear that the absence of psychological need satisfaction does not suggest its frustration and instead by including frustration-specific items to measure this area has allowed researchers to investigate aspects of the ARC that they may not be able to with satisfaction scales alone. The inverse of this is also true in that the presence of frustration does not imply that psychological need satisfaction is not being met (Vansteenkiste & Ryan, 2013).

Sheldon & Hilpert, (2012) make a suggestion that the subscales of the BPNS could be problematic (Sheldon & Hilpert, 2012). Furthermore, findings from this research propose that the ARC cannot be combined into one general need factor which would require an empirical investigation using advanced psychometric methods and larger samples. There may be however separate satisfaction and dissatisfaction constructs for each need (Sheldon & Hilpert, 2012).

### **Limitations of the Basic Psychological Need Satisfaction Scale**

Firstly, the major limitation of the BPNS, is the lack of reliable distinctions made between state and trait aspects of needs. There are potential consequences from this limitation, namely reliability and validity of assessment and the conclusions that are derived from research using inappropriate measures. It has also been suggested that the propositions of SDT can require further investigation and classification (Eriksson & Boman, 2018) as they are obtained from the assumption of fundamental psychological needs which extends to an assumption that the basic psychological needs of ARC are innate and universal (Deci & Ryan, 2000). Consideration from other theorists adds suggestions such as understanding psychological needs as being learned over time and not innate in everyone.

Research on the measurement of basic needs satisfaction has evaluated previous findings such as Johnston & Finney (2010) and conducted new psychometric evaluations of the BPNS in general (Johnston & Finney, 2010). This study provides three areas of focus. A

narrative view of past research on the BPNS has been collated with an examination of the dimensionality of the BPNS and concludes with the gathering of external validity evidence (Johnston & Finney, 2010). This study has very important limitations, however. Internal consistency Cronbach's alpha and test-retest reliability are not available for this study. There is also no mention of an overarching needs construct which is a strong limitation. For example, if a construct cannot be measured using a total score it arguably does not exist psychometrically and there are merely three subscales measuring three different but maybe related constructs.

Furthermore, lack of psychological need satisfaction is not an ideal indicator of its frustration (Vansteenkiste & Ryan, 2013) because the frustration of one's needs must include more than just deprivation of the basic psychological needs alone. The frustration of the basic psychological needs of ARC are predictive of an individual's problematic behaviours. Further research on the properties specific to areas of measurement may yield more concise methods and as has been mentioned there is a growing area of research into improving and increasing this understanding.

Eriksson and Bowman (2018) suggested that one of the main limitations of the BPNS is in the balance of item distribution in the three needs subscales. This theme continues in many of the psychological need satisfaction and frustration scales (Eriksson & Boman, 2018). Furthermore, an equal share of items across the three basic needs has been recommended (Sheldon & Hilpert, 2012). In this study, the BPNS includes 7 autonomy items, 6 competence items, and 8 relatedness items.

## **Conclusion**

Despite some limitations, the BPNS is the best available measure of psychological needs available to date. However, there is no evidence indicating what it is measuring, a state a trait or both and no adequate methodology was applied to distinguish state from trait and

examine the overall reliability of this scale and its subscales. Therefore, there is a need for research applying the most appropriate methodology available to date to investigate the BPNS.

### Chapter 3 Differentiating State from Trait

#### Classical Test Theory and Test-Retest Reliability

The early beginnings of Classical Test Theory (CTT) date back to September 1888 and to Francis Ysidro Edgeworth with his auditory of his paper to the British Association at Bath and unknown to him at the time, CTT was to become more influential than he could have imagined (Traub, 1997). Edgeworth was also credited with being the first to call  $r$  as being the coefficient of correlation (Traub, 1997). This initial proposition was expanded on by several prominent figures such as Karl Pearson and Francis Galton. The statistical theory of measurement score was further developed by Charles Spearman in the early part of the 20<sup>th</sup> Century and contributed to what CTT is today (Robert, 2006). The current system that is now generally accepted as CTT was introduced by Novick in 1966 (Borsboom, 2003). To this end the importance of CTT over the last century or so cannot be overstated.

The CTT model proposes three variables; observed, true, and error score random variables, expressed by the following formula:

$$X = T + E \quad (\text{Novick, 1966})$$

Here the observed score ( $X$ ) is the sum of a true score ( $T$ ) plus an error score ( $E$ ).

CTT assumes that the measurement error includes anything that cannot be allocated to the true score variance (Novick, 1966). Problematic here is that error cannot be attributed to different sources such as occasion or item and as such leaves the researcher unable to locate the exact source of error. Without this information improvements in the assessment and the design of the research are susceptible to being inadequate and inaccurate. The problem with a lack of determining the exact error source is that the researcher cannot find out what the big sources of error are and what small sources of error that do not have to be worried about. This means that comparison between different studies is problematic as they will usually use different samples and different raters etc (Bloch & Norman, 2012).

In CTT test-retest reliability assumes that the correlation coefficients which are assessed from the test-retest scores affords reliability from comparison at two different points in assessment time. The correlation coefficient is a reflection of the consistency of the test scores between occasions and is suggested as being reliable at measuring trait with a correlation of 0.70 or higher (Spielberger, 1970). Consideration is given to a measure which produces a correlation below 0.60 as being indicative of a state measure while a correlation above 0.70 is determined as being suggestive of a trait measure (Medvedev, 2017a; Spielberger, 1970). CTT is not suitable to assess the distinction between state and trait. This is due in part to being limited to only base this distinction on a single correlation between total test scores between occasions. This could mean that poor items may not be detected by test retest correlation which could affect the performance of a scale (Medvedev, 2017a).

### **Limitations of CTT methods**

To gain an understanding of G-theory it is useful to have knowledge of certain areas of CTT and the limitations that are included within (Brennan, 2010). CTT is limited to equating potential sources of variance as belonging to true score and measurement error. G-theory is advantageous for evaluating reliability over CTT by being able to differentiate stable and dynamic aspects in a measure (Medvedev et al., 2017; Medvedev et al., 2018; Paterson et al., 2018).

Brennan, (2010) has suggested that the simplicity of the CTT Model covers four important issues. The initial issue is that the user of the CTT model must make assumptions based on the true score and error score which are unobservable variables. Brennan also suggested that there are two ways in which an assumption can be made. The first way is if (T) is defined as the expected values of the observed scores. This would lead to the expected value of (E) being equal to zero. That is to say that the very fabric of the CTT assumes that

(E) and (T) are so closely related, where if the value of either (E) or (T) was known that the value of the other variable not known would be obvious.

The second issue is (T) in the CTT model, where (T) is definitely not a platonic true score as coined by Sutcliffe (1965) and Lord and Novick (1968). Here the interpretation of a platonic true score comes from the judgement of true scores as being valid or constant (Borsboom, 2005).

Thirdly, the CTT model has a high degree of similarity to a simple regression equation in that the error score (E) can be thought of as a model fit error. However, because the values of (T) and (E) respectively are unobservable variables which have no meaning except for any assumptions that are attributed to them, such a notion is misleading. For example, (T) is dependent on the other variables in the model meaning that any suggestion of (E) being the model fit error is problematic.

The fourth issue of the CTT model is that it is a tautology. The investigator using the CTT model has the power to decide what will be the true score and the error values making the true score and error investigator specific creations rather than being discovered variables.

### **Generalisability Theory (G-Theory)**

The development of G-Theory was introduced by Cronbach and other contributors (Cronbach et al., 1963) and extends CTT with an aim to improve reliability of evaluations. G-theory can be defined as being an analytical technique used in the assessment of psychometric instruments, which allows an estimation of error variance from any specific source and can be generalised to all possible contexts and situations (Cronbach et al., 1963; Salkind, 2010). There are four avenues in which G-Theory extends CTT. The first is by estimating sources of measurement error. Secondly, G-Theory models the use of measurement for norm referenced and domain referenced decisions. Thirdly, G-Theory produces generalisability coefficients tailored to the measurement. And lastly, highlighting

major sources of error which allows for a more efficient measurement to be designed (Shavelson et al., 1989). The most important function of G-Theory is to estimate multiple sources of measurement error. Generalisability analysis is conducted to examine true and error variance sources in a measure.

Very few constructs such as traits or states or unobserved phenomena that are of interest to psychologists for example are subject to instruments that provide precise measurements. G-Theory also uses mathematical statistics to extend the knowledge of CTT (Bloch & Norman, 2012), and the results and decisions that are then made from these results. The mathematical statistics acquired, allow for multiple definitions of true and error scores which CTT does not accurately cover. Fundamental to G Theory is the identification and estimation of any sources of error in a measurement. G-Theory builds on CTT, while also improving the Analysis of Variance (ANOVA) by using repeated measures ANOVA to compute variance components and estimate error sources and G coefficients. The sources identified as being responsible for variation usually include the person (P), the occasion (O) (on which the test or questionnaire are completed – including multiple occasions), and the item (I). These sources are analysed as individual sources and/or an interaction between the three characteristics (e.g., P x I, P x O, I x O, P x I x O). The difference here between G-Theory and CTT is that CTT is limited to only estimating variance due to a single source and does not include estimates for any interactions that may lead to sources of error.

G-theory is a useful method to evaluate and improve reliability and as such is becoming the golden standard to differentiate between stable and dynamic components and investigating sources of measurement error and generalisability of assessment scores in medicine and psychology alike (Medvedev et al., 2021; Medvedev et al., 2019; Medvedev et al., 2018). For instance, G-theory has been used in many areas of research which are benefiting from this new knowledge. Examples include in medical fields such as in the

measure of quality surgical safety checklists (Medvedev et al., 2019), and in measures of concussion symptoms through the use of the Rivermead Post Concussion Symptoms Questionnaire (RPQ), (Medvedev et al., 2018). Psychological research arenas also have many examples of benefit such as in quantifying symptoms of schizophrenia by analysing differences between enduring and dynamic aspects of psychopathology (Medvedev et al., 2021), measurement of perceived stress through the use of the Perceived Stress Scale (PSS-10), (Miller et al., 2020), and in evaluation of mindfulness based training through use of the widely used Five Facet Mindfulness Questionnaire (FFMQ), (Truong et al., 2020).

In generalisability theory the sources of error such as occasions, raters, and items are called facets and conditions refer to the levels of the facets (Shavelson et al., 1989) with these facets comparable to factors in ANOVA. The G-theory model formula in comparison to the CTT model formula above is stated as follows:

$$X = T + E(\text{person}) + E(\text{item}) + E(\text{occasion}) + E(\text{person} \times \text{item}) + E(\text{person} \times \text{occasion}) \\ + E(\text{person} \times \text{item} \times \text{occasion})$$

Where X is the observed score, T is the true score, and E is the error. As g-analysis is an estimate of the influence of one of the facets as mentioned, the extent of this influence can be generalised to all individual facets and the interaction between these facets and constructs over the assessment occasions and the sample population. This is expressed as a G-coefficient which ranges from 0 to 1. G-theory will distinguish between the relative and absolute g-coefficient for the object of measurement which is the person.

The term “noise” is employed here and refers to the relative contribution of different sources of variability in relation to the overall measurement error (Brennan, 2001). Each instance of noise can be displayed as the Intraclass Correlation Coefficient (ICC), where this coefficient has a range between 0 and 1. ICC indicates the difference between the total amount of observed variance and the amount of true score variance as a ratio. The ICC is

another indicator of the quality of a measurement (Bloch & Norman, 2012) and is formulated as follows:

$$\text{SNR} = \text{ES}^2 = \frac{\Delta X^2}{\sigma^2}$$

Therefore, an SNR definition for ICC, results in the following formula:

$$\text{ICC} = \frac{\text{SNR}}{1+\text{SNR}}$$

Where SNR = signal to noise ratio and is equal to the square of the effect size ( $\text{ES}^2$ ),  $\Delta X^2$  refers to constant change (variance) in the X variable, and  $\sigma^2$  refers to the total variance (Bloch & Norman, 2012). The G-coefficient is essentially similar to ICC as it is a ratio of true variance to the total variance including all sources of error.

The advantages of G -theory include the ability to partition sources of error variance. As G-theory is a multifaceted approach, this fact gives advantages over traditional methodologies such as CTT. Further advantages are the result of the researcher being able to investigate and modify questionnaires and scales through a D-study. This function enables improved reliability. G-study uses a four-step process as described below. There are generally two phases in the application of G Theory. Phase one includes the application of the Generalisability study (G-study) while the second phase follows on to the Decision study (D-study).

### **Generalisability Study (G-study)**

The G-study follows a four-step process. Firstly, defining the measurement design. A stable or dynamic component in this type of measurement is represented by the interaction between person and occasion (P x O) and its unique contribution is estimated by the State Component Index (SCI) that reflects scale sensitivity to state changes (Medvedev et al., 2017). To attribute the degree of variance to a state component in a score such as an individual item, an individual subscale (e.g., ARC) or the total score of an assessment (e.g.,

BPNS), a state component index (SCI) is computed. The formulation of coefficients was developed by Medvedev et al. (2017). The SCI is expressed in the following formula:

$$SCI = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_t^2}$$

Where the variance component of a state ( $\sigma_s^2 = \sigma_{po}^2$ ) is the error variance due to the person occasion interaction. This affects trait scores (Medvedev, 2017a). The interpretation for the SCI data follows G-theory logic, where a SCI coefficient of 1.00 would represent no trait component and a SCI = 0.50 would suggest equality between a state and trait variance component. A coefficient SCI > 0.60 is generally considered as a characteristic of a state measure (Medvedev et al., 2017). Using the same metric, a trait component index TCI coefficient can be utilised to discriminate a valid trait measure. The TCI is expressed in the following formula:

$$TCI = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_t^2}$$

To attribute the degree of variance to a trait component in a score such as an individual item, an individual subscale (e.g., ARC) or the total score of an assessment (e.g., the BPNS), a trait component index (TCI) is computed. Where the TCI can be used to measure a valid trait measure. The TCI uses the same metric as the SCI (Medvedev, 2017a).

Furthermore, SCI values are captured in the D-study (see next section) so that individual items can be evaluated. It was maintained that a high SCI ( $\geq 0.70$ ) are considered to reflect state items sensitive to changes of needs over time, while a low SCI ( $\leq 0.30$ ) are reflecting items measuring stable needs.

Secondly, the process of estimating variance components is the next step. Where variance components for individual facets of person (P), occasion (O), and item (I) and their

interactions were computed using repeated measures ANOVA. This then leads to the third step of the G-study which involves calculation of the absolute G-coefficient ( $G_a$ ) and the relative G-coefficient ( $G_r$ ). The G-coefficient is a reflection of how generalisable the test scores are from the sample population and over assessment occasions. The G-coefficients are expressed in the following formulas:

$$G_{\text{relative}} = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_\delta^2}; \sigma_\delta^2 = \frac{\sigma_{pi}^2}{ni} + \frac{\sigma_{po}^2}{no} + \frac{\sigma_{pio}^2}{nino}; \quad (\text{Shavelson et al., 1989})$$

$$G_{\text{absolute}} \simeq \Phi = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_{\delta_a}^2} \quad (\text{Shavelson et al., 1989})$$

Where  $n_i$  = number of items,  $n_o$  = number of occasions.

Both G relative and G absolute are estimates of the reliability of a trait measure. This is only if the object of the measurement is a person. It is generally accepted that a G-coefficient greater than 0.80 is characteristic of a trait measure, when the object of measurement is a person (Arterberry et al., 2014; Cardinet et al., 2011).

The final step involved a D-study analyses. This includes experimenting with measurement design aiming at optimising reliability of the full scale and its subscales and distinguishing between dynamic and enduring aspects of psychological needs. This optimisation allowed strict classification of items into either a state or trait component.

**Decision Studies (D-study)**

The goal of a decision study is to optimise the scale of measurement by deciding on assessment designs. The D-study is derived from information from a G-study which allows for an efficient design for the D-study. In this sense an efficient design would allow control of the largest error components (Kane, 2003). The two studies are distinguishable through G-theory where a G-study focuses on the development of a measurement procedure and the D-study applies that measurement procedure (Kane, 2003). Utilisation of the G-study affords the D-study the ability to minimise error through the design of a measurement method best

suited for the outputted data. Essentially, the D-study involves the manipulation of the measurement design. This is achieved through a series of decision making through interpretation of the results output during the manipulation process. Facet levels are the subject of increase or decrease dependant on the outputs. For example the facet levels of occasions or number of items can be manipulated to optimise the generalisability and therefore the reliability of assessment scores (Briesch et al., 2014).

Before a D-study takes place, the person making the decisions (in this case the researcher) firstly needs to define the universe of generalisation. This process involves reducing the levels of facets (facets are sources of error i.e., person, item, occasion) be either selecting or ignoring a facet so that the universe of generalisation can be defined. The researcher or decision maker then needs to decide what question of the G-study need to be asked so that the D-study achieves the goal of optimizing the measurement design.

### **Differentiating State from Trait with the use of Generalisability Theory**

Generalisability theory is a reliable psychometric method that was recently employed to differentiate between measures of state and trait. A trait can be referred to as relatively stable ways in which individuals display inter individual differences through tendencies, style, dispositional behaviours, and the particular ways in which an individual's thoughts are specific to that person (Hamaker et al., 2007). A state can be conceptualised as being a situational experience of an individual (Hamaker et al., 2007; Spielberger, 1970). A state is fundamentally actualised by the interaction between person and occasion and is suggested as being measured from present moment of actions specific to an individual (Medvedev, 2017a). The importance of a reliable measurement that can make the distinction between state and trait variance allows for measurement error to be accounted for and hence minimised. It is G-theory which provides a suitable method for assessing numerous factors that contribute to

measurement error and the interactions between these factors (Medvedev et al., 2017), and allows the distinction between state and trait variance components to be made.

If state and trait are not clearly identified, then the reliability and validity of measurements may be compromised. It is therefore necessary to apply suitable methods in the distinction between state and trait. A flow on from not making clear this distinction can affect interventions in a negative way. Furthermore, the importance of differentiation between trait and state especially in psychological or biological interventions cannot be overstated.

Because interventions aim at trait changes, the distinction between state and trait needs to be accurate so that the chance of relapse for individuals is minimised (Medvedev, 2019a). The reason for this is that a trait is considered to be established over a longer time period whereas a state could potentially change soon after an assessment for a variety of reasons. The same can be suggested for measuring state changes as the identification of the conditions in which changes occur can be established so that a specific treatment can be targeted.

Generalisability theory has been found to be an efficient, accurate and effective application to differentiate between stable and dynamic components in a measure while being attributed as the most robust psychometric procedure in the validation of stable and dynamic measurement tools.

### **Summary and Aim of Present Study**

The stark contrast between G-theory and CTT is highly discernible when measuring a distinction between stable and dynamic aspects. Using the CTT method does not allow any inclusion of variability either individually or between the interactions from person, item, and occasion or for any variability in test items. This is an important distinction to make as using this method would mean that the accuracy of a state/trait characteristic is very much limited. G-theory provides a much more robust analysis of error and as such improves the reliability of the overall measurement, the measurement subscales, and the individual items. G-theory

has been recommended as the most appropriate statistical method best suited to evaluate the state-trait distinction while providing reliability analysis and accurate evaluation of sources of measure error (Shavelson et al., 1989) of the BPNS and for that matter any psychometric measurement. G-theory was applied to investigate the overall scale, the three psychometric scales of the basic psychological needs, and the individual items from within these scales to determine if they were reliable measures of either dynamic or stable aspects of psychological need. A two-facet design with a random effects repeated measures model is to be used

## Chapter 4 Method and Results

### Participants

The current study included 116 introductory to psychology students who attended the University of Missouri, Columbia, USA and who participated in the study questionnaire for course credit. The participants completed the questionnaire on three separate occasions with approximately one-month intervals between assessments. This number of participants exceeded the minimum required sample size  $n = 43$  to achieve statistical power of 95% for detecting a small effect size ( $f = 0.25$ ) and met the requirements for a reliability study in medical research (Donner & Eliasziw, 1987; Shoukri et al., 2004). This sample included 71% females ( $n = 82$ ) and 29% males ( $n = 34$ ). The mean age of participants was 18.8 years with a range from 18 to 22 years while 18- and 19-year-olds accounted for 82.7% of the total participants. Most of the participants ( $n = 104$ , 89.6%) were of European ethnicity, 4% were Asian, 5% African American, and 0.86% American Indian/Alaska native. The study was (a) approved by the Institutional Review Board, University of Missouri -Columbia (IRB project number 2013684) (Appendix A2) and (b) by the University of Waikato Psychology Research and Ethics Committee. Ethics Approval number FS2021-03 (See Appendix A).

**Procedure**

The students were selected as part of an introduction to psychology course (Psych 1000), with all students being sent the survey by email and asked to respond in the same manner. The students participating in the study completed the first part (Time 1) of the BPNS in the middle of February of 2019 and then at two further time points (Time 2 middle of March 2019, Time 3 from the start to mid-April 2019). Each participant was asked to complete the same questionnaire over these three occasions. Participants were also asked to complete demographic information including, age, gender, and ethnicity. Information sheets were provided to participants so that they were fully informed as to the nature of the study and as such there was not expected to be any ill effects from data collection such as harm

and/or risk of any kind. Informed consent was obtained from all participants prior to their participation in the study.

### **Measure (BPNS)**

The BPNS (Deci & Ryan, 2000; Gagné, 2003) is a 21-item self report questionnaire designed to measure the basic psychological needs of ARC and addresses psychological need satisfaction in general as measured by these 3 subscale latent need factors. It is suggested that these needs must be satisfied for healthy human functioning and flourishing. This 21 item scale was developed from various measures of need satisfaction in the workplace including the generalisability of SDT to work organisations of different cultures (Deci et al., 2001), autonomy orientation and support (Gagné, 2003), and an investigation of goal pursuits (Deci & Ryan, 2000), and has further foundations of investigations that have a focus on individual motivation. Before any analysis could be conducted there were 10 items that needed to be reverse coded. Individual items were utilised using a 7-point Likert scale. Options for this scale ranged from 1 = “not at all true” to 7 = “very true” with the medium number 4 = “somewhat true”. Participants were asked to read the items carefully and with thought and respond by thinking how each item related to their lives and how true the item may have been for them. The total and individual subscale scores were calculated by adding the individual responses for each item.

### **Data Analyses**

Cronbach’s alpha, test-retest reliability coefficients, means, standard deviations and ICC were computed using IBM SPSS (Statistical Package for the Social Sciences) statistics 26 software. There were no missing data. EduG 6.1-e software was utilised to apply G Theory (Swiss Society for Research in Education Working Group, 2006) and involved using a four-step process described elsewhere (Lyndon et al., 2019; Medvedev et al., 2018).

Both the G-study and the D-study utilised a two-facet design with a random effects repeated measures model: person (P) by item (I) by occasion (O). This model is often represented as  $P \times I \times O$  with only the (I) facet being regarded as fixed and the P and O facets being infinite (Medvedev et al., 2017). As persons are the object of assessment they are not considered as a source of error however, items and occasions are defined as instrumentation facets, which are potential sources of error variance (Cardinet et al., 2011; Medvedev et al., 2018). The chapter three section of this study includes all G-study equations which were used to find estimations, including relative G-coefficient ( $G_r$ ), absolute G-coefficient ( $G_a$ ), and the variance components for each facet and interactions. G-study analyses included the entire 21 item BPNS

## **Results**

### **Descriptive statistics**

Descriptive statistics for the three subscales of the BPNS including autonomy, competence, and relatedness along with the total score of the scale are presented in Table 1, including means, standard deviations, internal consistency Cronbach's alpha, temporal reliability (test-retest coefficients) and ICC. Internal consistency Cronbach's alpha was acceptable for all subscales and the total scale ( $\geq 0.70$  over all three occasions with the exception being the autonomy subscale). The internal consistency for autonomy was below 0.70 over all three occasions, which is below expectations for consistent measures (Bland & Altman, 1997; Nunnally, 1994). Internal consistency as measured by Cronbach's alpha for the total BPNS over three occasions was good and ranged between 0.85 and 0.89, the relatedness subscale displayed good internal consistency over three occasions ranging between 0.80 and 0.86 with the competence subscale showing acceptable internal consistency over occasions two and three with a Cronbach's alpha values 0.74 and 0.78 respectively.

Internal consistency Cronbach’s alpha for time one was 0.66. Overall internal consistency over time was stronger for the total scale compared to subscales.

Both test-retest reliability and ICC coefficients indicated that autonomy, relatedness, and the total scale have temporal consistency acceptable for a trait measure (Spielberger, 1970). However, for competence, test-retest reliability was below expectations (< 0.70), while ICC was above 0.70, indicating acceptable reliability for a trait measure. There was no significant difference across occasions for all subscales and the total scale except for relatedness, where there was a significant difference between assessment at occasion 1 and assessment at occasion 2;  $t(116) = 2.15, p < 0.05$ . Overall internal consistency over time was stronger for the total scale compared to subscales.

**Table 1**

*Means, Standard Deviation (SD), Cronbach's Alpha, Intraclass Correlation Coefficient (ICC), and Test-retest Coefficients for the BPNS Subscales and the Total Scale (n=116 x 3 occasions)*

<b>Scale/Assessment</b>	<b>Occasion 1</b>	<b>Occasion 2</b>	<b>Occasion 3</b>	<b>ICC (95%CI)</b>
<b>Autonomy</b>				
Mean (SD)	33.91 (5.58)	32.82 (4.68)	32.18 (4.89)	
Cronbach’s alpha	0.59	0.67	0.66	
Test-retest ( $r^a$ )	-	0.72	0.73	0.74(0.67,0.80)
<b>Competence</b>				
Mean (SD)	29.85 (5.83)	30.19 (6.04)	29.90 (6.42)	
Cronbach’s alpha	0.66	0.74	0.78	
Test-retest ( $r^a$ )	-	0.64	0.65	0.71(0.63,0.78)
<b>Relatedness</b>				
Mean (SD)	45.19 (7.17) *	44.21 (7.81) *	44.60 (7.91)	
Cronbach’s alpha	0.80	0.86	0.85	
Test-retest ( $r^a$ )	-	0.76	0.77	0.78(0.72,0.84)
<b>BPNS Total</b>				
Mean (SD)	109.00 (15.57)	108.51 (16.75)	108.81 (17.30)	
Cronbach’s alpha	0.85	0.89	0.89	
Test-retest ( $r^a$ )	-	0.75	0.79	0.80(0.74,0.85)

*Note.* \*mean differences are significant with p value < 0.05; <sup>a</sup>Test-retest bivariate correlation between occasion 1 and subsequent occasion 2 and 3.

### **G-Study Findings**

G-Study variance components and generalisability coefficients are presented in Table 3. Overall, the total 21 item BPNS demonstrated acceptable generalisability of scores over sample population and occasions, as indicated by relative and absolute generalisability coefficients. After controlling for the true variance of a person, the largest amount of error variance in the total scale scores was due to occasion (59.1%). However, another 40.9% of error variance was accounted for by the interaction between person and occasion that indicated dynamic changes of psychological needs at individual level. While, for all subscales, generalisability coefficients both absolute and relative were below the cut-off point of 0.70 recommended for a reliable trait measure (Medvedev et al., 2017; Shavelson et al., 1989), all TCI reflecting proportion of trait variance relative to state variance were above the 0.80 mark. This means that other sources of error such as occasion and interactions between person, item and occasion affected reliability of subscales (Table 2).

**Table 2**

G-study Estimates of Variance Components Including State Component Index (SCI) and Trait Component Index (TCI) <sup>1</sup> for the BPNS Three Facet Subscales and the Total Scale

Source of variance	Differentiation variance	Relative error variance	% relative	Absolute error variance	% absolute
<b>P (BPNS Total)</b>	0.213	.....		.....	
I	.....	.....		(0.000)	0.0
O	.....	.....		0.042	<b>59.1</b>
PxI	.....	(0.00)	0.0	(0.000)	0.0
PxO	.....	0.029	100.0	0.01	40.9
IxO	.....	.....		(0.000)	0.0
PxIxO	.....	(0.00)	0.0	(0.000)	0.0
Sum of variances	0.213	0.029	100%	0.072	100%
Standard deviation	0.462	Relative SE:	0.171	Absolute SE:	0.26
Coef G relative/absolute	<b>0.88/0.75</b>	<b>SCI 0.04</b>	<b>TCI 0.96</b>		
<b>P (BPNS Autonomy Subscale)</b>	0.191	.....		.....	
I	.....	.....		(0.000)	0.0
O	.....	.....		0.017	11.7
PxI	.....	0.022	20.4	0.022	15.4
PxO	.....	0.027	30.6	0.027	18.8
IxO	.....	.....		0.018	12.5
PxIxO	.....	0.059	53.3	0.059	<b>41.6</b>
Sum of variances	0.191	0.108	100%	0.16	100%
Standard deviation	0.436	Relative SE:	0.329	Absolute SE:	0.378
Coef_G relative/absolute	<b>0.64/0.57</b>	<b>SCI 0.12</b>	<b>TCI 0.88</b>		
<b>P (BPNS CompetenceSubscale)</b>	0.219	.....		.....	
I	.....	.....		(0.000)	0.0
O	.....	.....		(0.000)	0.0
PxI	.....	0.061	14.2	0.061	34.9
PxO	.....	0.039	33.9	0.039	22.4
IxO	.....	.....		0.012	7.1
PxIxO	.....	0.063	51.8	0.063	<b>35.6</b>
Sum of variances	0.219	0.1654	100%	0.20	100%
Standard deviation	0.468	Relative SE:	0.404	Absolute SE:	0.419
Coef_G relative/ absolute	<b>0.57/0.55</b>	<b>SCI 0.15</b>	<b>TCI 0.85</b>		
<b>P (BPNS Relatedness Subscale)</b>	0.172	.....		.....	
I	.....	.....		(0.000)	0.0
O	.....	.....		0.111	<b>50.2</b>
PxI	.....	0.024	24.2	0.024	10.7
PxO	.....	0.028	29.0	0.028	12.8
IxO	.....	.....		0.013	5.7
PxIxO	.....	0.046	46.8	0.046	20.6
Sum of variances	0.172	0.097	100%	0.221	100%
Standard deviation	0.415	Relative SE:	0.312	Absolute SE:	0.470
Coef_G relative/ absolute	<b>0.64/0.44</b>	<b>SCI 0.14</b>	<b>TCI 0.86</b>		

Note. Standard errors (SE) and G-coefficients and for P x O x I design including the BPNS total and its

subscales (n=116); Bold values indicate generalisability coefficients and the largest sources of variance in each scale after accounting for person (trait) variance.

The autonomy subscale ( $G_r = 0.64$ ,  $G_a = 0.57$ ), competence subscale ( $G_r = 0.57$ ,  $G_a = 0.55$ ), and the relatedness subscale ( $G_r = 0.64$ ,  $G_a = 0.44$ ), all demonstrated an unreliable trait measure as indicated by both relative and absolute G coefficients being below 0.70 (Arterberry et al., 2014; Cardinet et al., 2011). The largest source of error variance in the autonomy subscale was attributed to the interaction between person-item-occasion (41.6%) which suggests that responses of people to specific items reflecting psychological needs are dependent on the occasion. The second largest source of error variance was accounted for by person-occasion interaction. Merely 18.8% of error variance was explained by person-occasion interaction and was reflected by the low SCI of 0.12 where a  $SCI > 0.60$  is expected for a valid state measure (Medvedev et al., 2017). The largest source of error variance in the relatedness subscale was due to Occasion (50.2%). However, another 20.6% of error variance was accounted for by the interaction between person, item, and occasion. Furthermore, the competence subscale displayed the largest source of error variance attributed to the interaction between person, item, and occasion (35.6%), while 34.9% of error variance was accounted for in the interaction between person and item.

#### **D Study Findings**

The D-study investigated properties of the individual items of the BPNS (items 1-21) so that state or trait psychological need patterns could be evaluated (see Appendix C22 – C42). Table 3 includes the variance components of person, person-occasion interaction (P x O), and SCI for all individual BPNS items. By using a cut-off point of 0.60 for SCI (Medvedev et al., 2017), to identify dynamic aspects of psychological needs. An inspection of the data illustrated that seven items (15, 8, 2, 18, 9, 11 and 4) were reflecting the most dynamic needs. Secondly, 2 items (3 and 10) are considered to measure mostly stable aspects of needs using a suggested cut off point of  $SCI \leq 0.30$  (Medvedev et al., 2017). The remaining items (6, 5, 19, 12, 20, 21, 1, 13, 14, 17 and 16) reflected both state and trait

aspects of psychological needs to differing degrees.

**Table 3**

*Variance Components of Person (P), Person x Occasion Interaction, and State Component Index (SCI) for Individual Items of the BPNS*

Items	P Variance	P x O (%) Variance	SCI
3. <b>R</b> Often, I do not feel very competent	0.86	0.44	<b>0.34</b>
10. I Have been able to learn interesting new skills recently	0.84	0.45	<b>0.35</b>
6. I get along with people I come into contact with.	0.81	0.53	0.40
5. People I know tell me I am good at what I do.	0.75	0.52	0.41
19. <b>R</b> I often do not feel very capable.	0.64	0.45	0.41
12. People in my life care about me	0.69	0.52	0.43
20. <b>R</b> There is not much opportunity for me to decide for myself how to do things in my daily life.	0.79	0.61	0.44
21. People are generally pretty friendly towards me.	0.57	0.49	0.46
1. I feel I am free to decide for myself how to live my life.	0.51	0.49	0.47
13. Most days I feel a sense of accomplishment from what I do.	0.65	0.62	0.49
14. People I interact with on a daily basis tend to take my feelings into consideration	0.56	0.54	0.49
17. I feel like I can pretty much be myself in my daily situations.	0.57	0.57	0.50
7. <b>R</b> I pretty much keep to myself and don't have a lot of social contacts.	0.61	0.63	0.51
16. <b>R</b> There are not many people that I am close to.	0.49	0.55	0.53
15. <b>R</b> In my life I do not get much of a chance to show how capable I am.	0.36	0.60	<b>0.63</b>
8. I generally feel free to express my ideas and opinions.	0.34	0.59	<b>0.63</b>
2. I really like the people I interact with.	0.23	0.58	<b>0.71</b>
18. <b>R</b> The people I interact with regularly do not seem to like me much.	0.08	0.60	<b>0.87</b>
9. I consider the people I regularly interact with to be my friends.	0.06	0.58	<b>0.89</b>
11. <b>R</b> In my daily life, I frequently have to do what I am told.	0.38	0.64	<b>0.94</b>
4. <b>R</b> I feel pressured in my life.	0.00	0.66	<b>1.00</b>

*Note.* Components and coefficients in bold indicate items measuring predominantly trait ( $SCI \leq 0.30$ ) and state ( $SCI \geq 0.6$ ). **R** denotes reverse coded items.

I then iteratively analysed combinations of individual items aiming to develop a reliable and sensitive state measure of psychological needs. The creation of a state subscale was achieved through analysing all 21- items, including all state items (15, 8, 2, 18, 9, 11 and 4 ( $SCI \geq 0.60$ ), which results in an SCI of 0.18 ( $G_r = 0.46$  and  $G_a = 0.31$ ) indicating that the full scale as it is, is probably a better representation of a trait measure. I then analysed individual items to see if I could improve the state subscale. To do this each individual item

recognised as a state item (i.e.,  $\geq 0.60$ ) starting from the item with the lowest SCI was individually analysed in comparison to the other state items. Firstly, I excluded only item 15. This produced a  $G_r = 0.23$  and  $G_a = 0.42$ , and an SCI of 0.20. Secondly, I made the decision to exclude items 15 and 8 which resulted in  $G_r = 0.07$  and  $G_a = 0.20$ , SCI = 0.43 the decision was made to then exclude items 15, 8, and 2 this resulted in  $G_r = 0.03$ , and  $G_a = 0.09$ , SCI = 0.58. My next decision was to exclude items 15, 8, 2, 18;  $G_r = 0.00$ , and  $G_a = 0.08$ , SCI = 0.00. I decided to include item 18 and exclude item 9 (along with 15, 8, 2) This produced,  $G_r = 0.00$  and  $G_a = 0.00$ ; SCI = 1.00. Following this result the decision was then made to exclude 15, 8, and 9 leaving items 4, 11, 18, 2 as a possible scale where  $G_r = 0.00$  and  $G_a = 0.00$ ; SCI = 1.00. These results were similar to the previous decision with only a negligible difference in the P x O variance. Therefore, there are two optimal state subscales that can be utilised from the full 21 items (4, 11, and 18) & (2, 4, 11, and 18)

Optimised trait subscales are presented in bold (Table 4). Further analysis of the individual subscales of ARC showed that only one subscale (relatedness) can be modified into a reliable trait measure (2, 9, 18). This relatedness state measure includes items 2, 9, and 18 with items 6, 7, 12, and 16 being excluded. This analysis followed the same decision-making process as described above for the state subscale.

**Table 4**

*D Optimising Design – D Study Including G Absolute, G Relative, and SCI*

Items – (excluded to optimise state measure)	P Variance	P X O (%) Variance	G absolute	G relative	SCI
4, 11, 9, 18, 2, 8, 15 – All state items	0.075	0.017	0.46	0.31	0.18
4, 11, 9, 18, 2, 8 (ex : 15)	0.074	0.019	0.42	0.23	0.20
4, 11, 9, 18, 2 (ex : 15, 8)	0.032	0.024	0.20	0.07	0.43
4, 11, 9, 18 (ex : 15, 8, 2)	0.016	0.022	0.09	0.03	0.58
4, 11, 9 (ex : 15, 8, 2, 18)	0.279	0.032	0.08	0.00	0.00
<b>4, 11, 18 (ex : 15, 8, 2, 9)</b>	<b>0.000</b>	<b>0.059</b>	<b>0.00</b>	<b>0.00</b>	<b>1.00</b>
<b>4, 11, 18, 2 (ex : 15, 8, 9)</b>	<b>0.000</b>	<b>0.039</b>	<b>0.00</b>	<b>0.00</b>	<b>1.00</b>
Subscales:					
Autonomy (1, 4, 8, 11, 14, 17, 20)	0.191	0.027	0.57	0.64	0.12
1, 4, 8, 11, 14, 17 (ex: 20)	0.174	0.016	0.55	0.61	0.08
4, 8, 11, 14, 17 (ex: 1, 20)	0.241	0.034	0.60	0.64	0.12
4, 8, 11, 17 (ex: 1, 14, 20)	0.093	0.014	0.26	0.34	0.13
4, 8, 11 (ex: 1, 14, 17, 20)	0.094	0.010	0.23	0.31	0.10
Competence (3, 5, 10, 13, 15, 19)	0.219	0.039	0.55	0.57	0.15
5, 10, 13, 15, 19 (ex: 3)	0.207	0.040	0.49	0.51	0.16
5, 13, 15, 19 (ex: 3, 10)	0.174	0.032	0.40	0.42	0.16
13, 15, 19 (ex: 3, 5, 10)	0.221	0.035	0.39	0.42	0.14
Relatedness (2, 6, 7, 9, 12, 16, 18, 21)	0.172	0.028	0.44	0.64	0.14
2, 7, 9, 12, 16, 18, 21 (ex: 6)	0.149	0.031	0.38	0.57	0.17
2, 7, 9, 16, 18, 21(ex: 6, 12)	0.152	0.040	0.33	0.53	0.21
2, 7, 12, 16, 21(ex: 6, 12, 21)	0.111	0.040	0.22	0.40	0.26
2, 9, 16, 18 (ex: 6, 7, 12, 21)	0.072	0.030	0.13	0.28	0.29
<b>2, 9, 18 (ex: 6, 7, 12, 16, 21)</b>	<b>0.000</b>	<b>0.044</b>	<b>0.00</b>	<b>0.00</b>	<b>1.00</b>

*Note.* Components and coefficients in bold indicate items excluded that are at the maximum optimal trait measure.

Furthermore, after establishment of a reliable and sensitive state measure for the overall scale, the next step in the process involves decision making in the optimisation of the individual subscales. Starting with autonomy, the same process was used as for the total scale D-study in so much that decisions were made following investigation of individual items of each subscale starting with the individual item with the lowest SCI. All items of the autonomy subscale (excluding all other items) displayed a  $G_r = 0.64$  and a  $G_a = 0.57$ . Exclusion of Item 20 (Lowest SCI) resulted in  $G_r = 0.61$  and a  $G_a = 0.55$ . This allowed the decision of adding item 1 to the excluded item list and resulted in  $G_r = 0.64$  and  $G_a = 0.60$ . Item 14 was then added and resulted in  $G_r = 0.34$  and  $G_a = 0.26$ . Following this decision, item 17 was added to the items to exclude list. Results from this analysis showed a  $G_r = 0.31$  and  $G_a = 0.23$ . No further analysis could take place as the subscale had three items left (Shoukri et al., 2004). The analysis displays that a reliable state measure for the autonomy subscale cannot be established.

This procedure was replicated with the competence subscale where excluding items 3, 5, and 10 did not improve the  $G_r$  or the  $G_a$  or indeed the SCI. This again displays that a reliable state measure for the competence subscale cannot be established. However, the relatedness subscale can be modified into a reliable state measure. Starting with all items of this subscale a  $G_r = 0.64$  and  $G_a = 0.44$  result with an SCI of 0.14 are found. Excluding items with the lowest to highest SCI including items 6, 12, 21, 7, and 16 results in a  $G_r = 0.00$  and a  $G_a = 0.00$  and an SCI = 1.00

Negatively worded items (3, 19, 20, 7, 16, 15, 18, 11 and 4) that have been reverse coded as denoted by **R** in Table 4 are found across dynamic and stable components, meaning that we cannot attribute the SCI measurement to the wording of an item

## Chapter 5 Discussion

The aim of this study was to differentiate between stable and dynamic aspects of psychological needs by examining psychometric properties and reliability of the BPNS using G-theory. This study has shown that the BPNS total scale showed good temporal reliability and generalisability of scores across persons and occasions in measuring psychological needs as a trait for the total scale ( $G r/a = 0.88/0.75$ ). This indicates that the overall level of needs or neediness is relatively stable for each individual while there are differences across individuals in their neediness trait levels. However, three BPNS subscales (e.g. autonomy, relatedness, and competence) appeared less reliable over time with G coefficients being below acceptable cut-off point of 0.60 (Arterberry et al., 2014; Cardinet et al., 2011). Less than 60% of variance in the subscales scores is explained by true differences between persons while over 40% attributed to measurement error mainly explained by occasion and person-occasion.

The overall good reliability of the total BPNS and dynamic aspects of the individual subscales, suggest the overarching latent trait of neediness that varies across individuals while specific needs are state like and therefore can shift from one aspect to another depending on circumstances of individual's life. Measurement error due to occasion and person-occasion found in individual subscales (e.g., ARC) indicates that specific needs are changing over time. These findings are consistent with Lyndon et al. (2019), a pioneering study on academic motivation showing that motivational priority shifts across intrinsic and extrinsic aspects over time with the overall motivation level of a person remaining stable.

A further examination of the individual subscales illustrated that the both the autonomy and relatedness subscales have the highest number of dynamic items at three each respectively items while the competence subscale not only has the least number of dynamic items (one) but also has the highest number of stable items (two). This must also be

compared to the individual subscales. All of the subscales of the BPNS have items that are measuring both state and trait.

The autonomy subscale shows that the greatest source of error variance is attributed to the interaction between the person, item, and occasion (41.6%) which suggests that the responses of people to specific items are dependent on the occasion. The next highest source of error is the interaction between person and occasion (18.8%) representing a state. Of the seven autonomy items, 4, 8, and 11 have an SCI which suggests that these items are state measures while four items are (1, 14, 17, and 20) are measuring both state and trait. The relatedness subscale shows the greatest source of error variance is coming from the occasion (50.2%) while 20.6% of the source of error variance is coming from the interaction between person, item, and occasion. Of the eight items of this subscale, items 2, 9, and 18 are said to measure state while items 6, 7, 12, 16, and 21 are measuring both state and trait. Finally, the competence subscale displays the greatest source of error variance as coming from the interaction between person, item, and occasion (35.6), while the interaction of person and item closely follows with 34.9% (representing a state). Interestingly the test-retest reliability for this subscale was below expectations ( $< 0.70$ ), while ICC was above 0.70, indicating acceptable reliability for a trait measure. Half of the individual items (items 5, 13, 19) that are included in the competence subscale are measuring both state and trait ( $0.3 \leq \text{item} \leq 0.7$ ), with item 15 - In my life I do not get much of a chance to show how capable I am, being considered a state item (i.e.,  $\text{SCI} \geq 0.70$ ). Items 3 and 10 display as a trait measure.

The D study aimed to focus on individual items to examine stable and dynamic variance components. Initial analysis showed that seven items were considered to mostly reflect state components of psychological needs. Of these items, three are measuring the need for autonomy (4, 8, and 11), three are measuring the need for competence (2, 9, and 18) and one (15) is measuring the need for relatedness. These needs are the most dynamic and hence

potentially amendable through intervention aiming at internal or external satisfaction of those needs. By consistent addressing of the most amendable needs the overall neediness trait can be altered over time. In other words, if a state of balance is reinforced it will finally become a trait. In fact recently G-theory was used to distinguish dynamic symptoms of schizophrenia (Medvedev et al., 2021). For example, item 15 – “In my life, I do not get much of a chance to show how capable I am” is environmentally based and therefore reflects a dynamic component of motivation (SCI = 0.63)

Two items were considered to mostly reflect trait components of needs (items 3, and 10 – both items measuring competence). These needs are trait like and very difficult to change and evaluating such needs is important because high level of enduring needs may put an individual at risk by affecting well-being and quality of life (Deci & Ryan, 2000). People with high level of enduring (trait) needs, require an effective intervention focused on amendable needs. For example, item 19 – “I often do not feel very capable” reflects a more stable component of motivation (SCI = 0.41).

The remaining items (in order of lowest to highest SCI: 6, 5, 19, 12, 20, 21, 1, 13, 14, 17, 7, and 16) were considered to measure both stable and dynamic aspects of motivation as they are not clearly measuring either state or trait. By combining these items that are seen to be measuring both state and trait aspects of motivation, there is a very strong proportion of trait variance (50% and above), all state variances usually cancel each other out as they are not occurring at the same time.

However, with training, people can be taught how to be more satisfied with their psychological needs. By using the two items as mentioned above (items 15 and 19) as an example, it can be suggested that we all internally have the propensity for high capability, but we may not get a chance to show this as item 15 illustrates, while item 19 refers to a trait based internal feeling of capability. This is further strengthened when focusing on item 7R –

I pretty much keep to myself and don't have a lot of social contacts. These people can be trained to develop social relationships by introducing an intervention in the form of a course that is readily available to both children and adults. This intervention type focuses on the development of social skills.

The advantage in this study of using G-theory is determining which items or subscales are measuring stable or dynamic aspects of psychological needs (e.g., ARC) while being able to evaluate the overall reliability and generalisability of assessment scores that no other form of analyses can offer to date.

### **Developing a Brief Measure of Psychological Needs**

A brief state measure of psychological needs was developed. This scale includes the following items: 2 - I really like the people I interact with, 4 - I feel pressured in my life, 11 - In my daily life, I frequently have to do what I am told and item 18 - The people I interact with regularly do not seem to like me much. The development of this brief state scale was achieved through a D-study optimising design. All items that were considered to be a measure of state (i.e.,  $SCI \geq 0.70$ ) were analysed as a separate scale from the rest of the individual items. The initial group included items 4, 11, 18, and 2 as above and items 9 - I consider the people I regularly interact with to be my friends, 8 - I generally feel free to express my ideas and opinions, and item 15 - In my life I do not get much of a chance to show how capable I am.

These seven items were placed in order of the item with the highest SCI i.e., item 4 in descending order to item 15 with the lowest SCI for that group. The initial SCI which included all seven items displayed an SCI of 0.18 (Table 4). Based on an optimising design D-study the logical first step was to exclude the item with the lowest SCI (item 15) to investigate what changes may occur to the group SCI. Excluding item 15 did indeed increase the SCI to 0.20. The next step was to exclude (along with item 15) the next item with the next

lowest SCI which was item 8. This step produced an increase in the SCI to 0.43. The next item to exclude was item 2. This increased the SCI to 0.58. Following on the decision to exclude item 18 resulted in an SCI of 0. Item 18 was then reinstated into the original group and instead item 9 was excluded (along with 15, 8, and 2). This exclusion produced an SCI of 1 (including items 4, 11, and 18) or a brief state subscale. However, to produce an optimised state subscale, the decision to include other state items to see if the SCI would remain at 1 was made. This step involved including item 2. Analysis showed that in fact including this item along with items 4, 11, and 18 produced an optimised brief state subscale.

The optimised brief state subscale displays a person variance of 0 together with a G-absolute and G-relative coefficient of 0. This would suggest that using the optimised items as a state subscale would have no measure of a trait component. The benefit of this includes being able to measure psychological needs as a state.

### **Implications**

The findings of this study suggest that a reliable and valid dynamic (state) measure of the overall needs of the BPNS can be developed using item 2 – I really like the people I interact with (relatedness), item 4 – I feel pressure in my life (autonomy), item 11 - In my daily life, I frequently have to do what I am told, and item 18 - The people I interact with regularly do not seem to like me much (relatedness), items 4, 11, and 18 also produced an optimised dynamic (state) measure. State needs can also be measured using these three items but using this would cover fewer dynamic aspects which is a disadvantage. However, the best combination for a reliable state measure is items 2, 4, 11, and 18. Any other combinations of items could not produce a better result than this (i.e., SCI = 1.00 G coefficients = 0.00).

Interestingly the items from this new state measure come from only two subscales which are autonomy and relatedness. This suggests that only autonomy and relatedness have a strong state component, while competence does not seem to have a high sensitivity to state

change i.e., more stable. This is further evidenced by looking at sources of error (Table 2) to find that the largest sources of error for the competence subscale is coming from the interaction of person- item which suggests that the generalisability of this scale is not low because it is measuring state but because there is an interaction between people and item. This means that different people may interpret some items differently independent from their neediness trait.

### **D Study Implications**

The process of the D study included an attempt to develop a state subscale from each individual subscale. Firstly, the autonomy subscale could not produce a reliable state subscale. By excluding individual items with the lowest SCI one by one the SCI for the overall autonomy subscale did not increase and in fact the person and person variance interactions also reduced indicating that autonomy as a psychological need is not a good measure of state. Secondly, the competence subscale analysis also displayed results that suggested that a state subscale could not be produced. Firstly, I removed the competence item with the lowest SCI to see if the overall competence SCI would improve. In this case that was item 3. This only improved the SCI marginally. I then continued to remove competence items with the lowest SCI until there were only three items left. At this stage there were no further items to remove. However, the relatedness subscale did produce a reliable and sensitive state subscale. This was achieved by removing the individual items one at a time with the lowest SCI to see if the overall relatedness subscale SCI would improve. This indicates that relatedness can be assessed as a state by using item 2 – I really like to interact with people, item 9 – I consider the people I regularly interact with to be my friends, and item 18 – The people I interact with regularly do not seem to like me much. In conclusion, the implications of this study suggest that state can be measured with the overall scale, or with autonomy and relatedness together, as can relatedness be measured alone as a state.

### **Limitations**

The following limitations are acknowledged. Firstly, the small age range of participants and secondly the large difference in gendered results. Specifically, that the results of this study could have been impacted by the large disproportional gender distribution with males being under-represented in the sample. Students were also the only participants of this study and therefore further investigations with diverse populations to strengthen the generalisability of my findings may be needed. There is however, evidence that a general factor of personality is universal across the human population which is inclusive of stable and dynamic patterns (Linden et al., 2018), this would suggest that the findings of this study could be generalisable outside of the sample population. Future research should use different samples to confirm replicability of the current study.

### **Directions for Further Research**

The results from the current study together with the literature that has been reviewed suggest that psychological needs appear similar to a personality trait. Generalisability coefficients (between 0.75 and 0.89 respectively) from the generalisability analysis of the big five (Arterberry et al., 2014) and the generalisability coefficients from the total scale of the BPNS of psychological needs (0.75 and 0.88 respectively) are very similar. It is therefore suggested that these needs are a potential which every individual possesses to a different degree, some people are more needy while some are less needy regardless of their environments. The suggestion here is that psychological needs can be said to potentially be a personality trait.

Future research could endeavour to examine the expansion of the “Big Five” model of personality as proposed by Costa & McCrae, 1992; DeYoung, Quilty, & Peterson, 2007; Goldberg, 1990, 1999; McCrae & John, 1992, (Milfont & Sibley, 2012), to include a sixth model of personality called neediness. This would lend support to works completed on

the limitations of the five facet model of personality, where further examination of areas such as explanations for human behaviour and experiences (McAdams, 1992), could be investigated. Future studies may examine (a) to what extent are individual needs shaped by their childhood experiences? Or (b) which developmental pathway/s predicts the level of an individual's needs in relation to ARC? This could be researched to give us a more enriched and deeper understanding of human functioning. A hypothesis could be formulated that in childhood if an individual has their needs satisfied then they would be less needy as adults and conversely if in childhood psychological needs of an individual are not satisfied due to deprivation then in adulthood their level of neediness may be higher. There is also credence through a review of literature in this study that psychological need measures still require further investigation to improve the measurement of psychological need satisfaction.

### **Conclusion**

The findings of this study provided preliminary support for the assertion that (1) the overall good reliability of the BPNS and dynamic aspects of the individual subscales, suggests that the overarching latent trait of neediness varies across individuals. And (2), specific needs are state-like and therefore can shift from one aspect to another depending on circumstances of an individual's life. The creation of a brief dynamic need scale containing two items from the autonomy subscale and the relatedness subscale provides researchers with an opportunity to measure psychological needs as a state.

Trait characteristics were examined in this study and reliability did not improve for the total scale. The process of removing state items to improve reliability proved ineffective suggesting that they are all useful to measure a trait because all items reflect a trait component to a different extent. The conclusion from this process is very important: if reliability does not improve by removing state items, it supports the notion that the total need trait is relatively stable. If one item or one subscale displays an increase in needs another item

or subscale decreases in relation to the total scale remaining relatively stable. This is reflected in the G absolute coefficient of 0.88 and G relative coefficient of 0.75, which means this scale measures needs as a stable construct. This leads to the finding that needs are an evolutionary potential, something that every individual possess to some extent. Some people are therefore more needy while some are less needy regardless of the environment in which they find themselves, it is simply their personality trait.

In conclusion the study using G-theory was much needed in the field because until now the distinction between dynamic and stable aspects of psychological constructs has not been very well established. G-theory was applied to investigate the overall scale, the three psychometric scales of the basic psychological needs, and the individual items from within these scales to determine if they were reliable measures of either dynamic or stable aspects of psychological need. This research also adds to the current literature in the field of SDT and addresses limitations of the previous work such as lack of state-trait distinction in the BPNS using appropriate methodology.

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**Appendix A – (Ethics approval – The University of Waikato)**

*Te Wānanga o Ngā Kete* | **Division of Arts,  
Law, Psychology & Social Sciences**

The University of Waikato  
Private Bag 3105  
Hamilton 3240  
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THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

Scott Drabble

Oleg Medvedev

Psychology

2 March 2021

Dear Scott

Re: **FS2021-03: Investigating Dynamic and Stable Aspects of Psychological Needs Using Generalisability Theory**

Thank you for submitting the additional information we requested, in relation to your application to the ALPSS Human Research Ethics Committee. The Committee is now pleased to offer formal approval for your research activities, as detailed in your application.

We encourage you to contact the Committee should issues arise during your data collection, or should you wish to add further research activities or make changes to your project as it unfolds. We wish you all the best with your research. Thank you for engaging with the process of ethical review.

Kind regards,

A handwritten signature in black ink, appearing to be 'N. Cooper'.

Nathan Cooper, Chair  
*Division of Arts, Law, Psychology & Social Sciences Human Research Ethics Committee*

**Appendix A2 (Ethics approval – University of Missouri)**



**Institutional Review Board |**  
 University of Missouri-Columbia  
 FWA Number: 0002876  
 IRB Registration Numbers: 00000731, 00009014

482 McReynolds Hall  
 Columbia, MO 65211  
 573-882-3181  
 irb@missouri.edu

February 05, 2019

Principal Investigator: Steven  
 Pratscher Department:  
 Psychological Sciences

Your IRB Application to project entitled Psychological Adjustment: Three-part study was reviewed and approved by the MU Institutional Review Board according to the terms and conditions described below:

IRB Project Number	2013684
IRB Review Number	244649
Initial Application Approval Date	February 04, 2019
IRB Expiration Date	February 04, 2020
Level of Review	Expedited
Application Status	Approved
Project Status	Active - Open to Enrollment
Expedited Categories	45 CFR 46.110.a(f)(7)
Risk Level	Minimal Risk
Type of Consent	Consent with Waiver of Documentation
HIPAA Category	No HIPAA
	IRB Approved Consent Document
	Updated protocol
	Updated
	recruitment ad
	Approved
	Documents

Depression, anxiety, and stress scale  
 Trait mindfulness scale- attention and awareness scale  
 Interpersonal mindfulness scale

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
2. All unanticipated problems must be reported to the IRB on the Event Report within 5 business days of becoming aware of the problem. Unanticipated problems are defined as events that are unexpected, related or possibly related to the research, and suggests the research places subjects or others at a greater risk of harm than was previously known or recognized. If the unanticipated problem was a death, this is reportable to the IRB within 24 hours on the Death Report.

3. On-site deaths that are not unanticipated problems must be reported within 5 days of awareness on the Death Report, unless the study is such that you have no way of knowing a death has occurred, or an individual dies more than 30 days after s/he has stopped or completed all study procedures/interventions and required follow-up.
4. All deviations (non-compliance) must be reported to the IRB on the Event Report within 5 business days of becoming aware of the deviation.
5. All changes must be IRB approved prior to implementation unless they are intended to reduce immediate risk. All changes must be submitted on the Amendment Form.
6. All recruitment materials and methods must be approved by the IRB prior to being used.
7. The project-generated annual report must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date. If the study is complete, the Completion/Withdrawal Form may be submitted in lieu of the annual report.
8. Securely maintain all research records for a period of seven years from the project completion date or longer depending on the sponsor's record keeping requirements.
9. Utilize the IRB stamped consent documents and other approved research documents located within the document storage section of eCompliance. These documents are highlighted green.

If you are offering subject payments and would like more information about research participant payments, please click here to view the MU Business Policy and Procedure: [http://bppm.missouri.edu/chapter2/2\\_250.html](http://bppm.missouri.edu/chapter2/2_250.html)

If you have any questions, please contact the IRB at 573-882-3181 or [irb@missouri.edu](mailto:irb@missouri.edu).

Thank you,  
MU Institutional Review Board

**Appendix B (BPNS questionnaire)**

## Basic Psychological Need Satisfaction in General Questionnaire

## Feelings I Have

Please read each of the following items carefully, thinking about how it relates to your life, and then indicate how true it is for you. Use the following scale to respond:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

1. I feel like I am free to decide for myself how to live my life.
2. I really like the people I interact with.
3. Often, I do not feel very competent.
4. I feel pressured in my life.
5. People I know tell me I am good at what I do.
6. I get along with people I come into contact with.
7. I pretty much keep to myself and don't have a lot of social contacts.
8. I generally feel free to express my ideas and opinions.
9. I consider the people I regularly interact with to be my friends.
10. I have been able to learn interesting new skills recently.
11. In my daily life, I frequently have to do what I am told.
12. People in my life care about me.
13. Most days I feel a sense of accomplishment from what I do.
14. People I interact with on a daily basis tend to take my feelings into consideration.
15. In my life I do not get much of a chance to show how capable I am.
16. There are not many people that I am close to.
17. I feel like I can pretty much be myself in my daily situations.
18. The people I interact with regularly do not seem to like me much.

19. I often do not feel very capable.
20. There is not much opportunity for me to decide for myself how to do things in my daily life.
21. People are generally pretty friendly towards me.

**Scoring information.**Autonomy items:

1, 4(R), 8, 11(R), 14, 17, 20(R)

Competence items:

3(R), 5, 10, 13, 15(R), 19(R)

Relatedness items:

2, 6, 7(R), 9, 12, 16(R), 18(R), 21

**Appendix C1 - C21 (G Theory analysis)**

Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

G Study Table  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.551	.....	.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.091	15.6
	.....	PI	.....		.....	
	.....	PO	0.493	100.0	0.493	84.4
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.551		0.493	100%	0.584	100%
Standard deviation	0.742		Relative SE: 0.702		Absolute SE: 0.764	
Coef_G relative	0.53					
Coef_G absolute	0.49					

Grand mean for levels used: 5.313  
 Variance error of the mean for levels used: 0.100  
 Standard error of the grand mean: 0.317

**Appendix C2**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.239		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.462	44.2
	.....	PI	.....		.....	
	.....	PO	0.584	100.0	0.584	55.8
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.239		0.584	100%	1.046	100%
Standard deviation	0.489		Relative SE: 0.764		Absolute SE: 1.023	
Coef_G relative	0.29					
Coef_G absolute	0.19					

Grand mean for levels used: 4.779  
 Variance error of the mean for levels used: 0.469  
 Standard error of the grand mean: 0.685

**Appendix C3**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.866		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.078	15.0
	.....	PI	.....		.....	
	.....	PO	0.440	100.0	0.440	85.0
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.866		0.440	100%	0.518	100%
Standard deviation	0.930		Relative SE: 0.663		Absolute SE: 0.720	
Coef_G relative	0.66					
Coef_G absolute	0.63					

Grand mean for levels used: 5.250  
 Variance error of the mean for levels used: 0.089  
 Standard error of the grand mean: 0.299

**Appendix C4**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	(0.000)		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.366	35.7
	.....	PI	.....		.....	
	.....	PO	0.660	100.0	0.660	64.3
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.000		0.660	100%	1.026	100%
Standard deviation	0.000		Relative SE: 0.812		Absolute SE: 1.013	
Coef_G relative	0.00					
Coef_G absolute	0.00					

Grand mean for levels used: 5.032  
 Variance error of the mean for levels used: 0.371  
 Standard error of the grand mean: 0.610

**Appendix C5**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.756		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.056	9.6
	.....	PI	.....		.....	
	.....	PO	0.528	100.0	0.528	90.4
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.756		0.528	100%	0.583	100%
Standard deviation	0.869		Relative SE: 0.726		Absolute SE: 0.764	
Coef_G relative	0.59					
Coef_G absolute	0.56					

Grand mean for levels used: 4.902  
 Variance error of the mean for levels used: 0.067  
 Standard error of the grand mean: 0.258

**Appendix C6**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.812		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.107	16.7
	.....	PI	.....		.....	
	.....	PO	0.534	100.0	0.534	83.3
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.812		0.534	100%	0.641	100%
Standard deviation	0.901		Relative SE: 0.731		Absolute SE: 0.801	
Coef_G relative	0.60					
Coef_G absolute	0.56					

Grand mean for levels used: 5.244  
 Variance error of the mean for levels used: 0.118  
 Standard error of the grand mean: 0.344

**Appendix C7**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.614		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.023	3.5
	.....	PI	.....		.....	
	.....	PO	0.635	100.0	0.635	96.5
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.614		0.635	100%	0.658	100%
Standard deviation	0.784		Relative SE: 0.797		Absolute SE: 0.811	
Coef_G relative	0.49					
Coef_G absolute	0.48					

Grand mean for levels used: 5.313  
 Variance error of the mean for levels used: 0.034  
 Standard error of the grand mean: 0.184

**Appendix C8**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.345		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.124	17.3
	.....	PI	.....		.....	
	.....	PO	0.592	100.0	0.592	82.7
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.345		0.592	100%	0.716	100%
Standard deviation	0.587		Relative SE: 0.770		Absolute SE: 0.846	
Coef_G relative	0.37					
Coef_G absolute	0.32					

Grand mean for levels used: 5.339  
 Variance error of the mean for levels used: 0.132  
 Standard error of the grand mean: 0.364

**Appendix C9**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 10 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.069		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.515	46.9
	.....	PI	.....		.....	
	.....	PO	0.583	100.0	0.583	53.1
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.069		0.583	100%	1.099	100%
Standard deviation	0.263		Relative SE: 0.764		Absolute SE: 1.048	
Coef_G relative	0.11					
Coef_G absolute	0.06					

Grand mean for levels used: 4.920  
 Variance error of the mean for levels used: 0.521  
 Standard error of the grand mean: 0.722

**Appendix C10**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 11 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.846		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.129	22.2
	.....	PI	.....		.....	
	.....	PO	0.454	100.0	0.454	77.8
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.846		0.454	100%	0.583	100%
Standard deviation	0.920		Relative SE: 0.674		Absolute SE: 0.764	
Coef_G relative	0.65					
Coef_G absolute	0.59					

Grand mean for levels used: 5.345  
 Variance error of the mean for levels used: 0.140  
 Standard error of the grand mean: 0.375

**Appendix C11**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.038		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.459	41.6
	.....	PI	.....		.....	
	.....	PO	0.646	100.0	0.646	58.4
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.038		0.646	100%	1.105	100%
Standard deviation	0.196		Relative SE: 0.804		Absolute SE: 1.051	
Coef_G relative	0.06					
Coef_G absolute	0.03					

Grand mean for levels used: 5.086  
 Variance error of the mean for levels used: 0.465  
 Standard error of the grand mean: 0.682

**Appendix C12**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.697		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.012	2.3
	.....	PI	.....		.....	
	.....	PO	0.524	100.0	0.524	97.7
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.697		0.524	100%	0.536	100%
Standard deviation	0.835		Relative SE: 0.724		Absolute SE: 0.732	
Coef_G relative	0.57					
Coef_G absolute	0.57					

Grand mean for levels used: 5.026  
 Variance error of the mean for levels used: 0.023  
 Standard error of the grand mean: 0.151

**Appendix C13**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.653		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.144	18.8
	.....	PI	.....		.....	
	.....	PO	0.621	100.0	0.621	81.2
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.653		0.621	100%	0.765	100%
Standard deviation	0.808		Relative SE: 0.788		Absolute SE: 0.875	
Coef_G relative	0.51					
Coef_G absolute	0.46					

Grand mean for levels used: 5.244  
 Variance error of the mean for levels used: 0.155  
 Standard error of the grand mean: 0.394

**Appendix C14**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.560		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.019	3.3
	.....	PI	.....		.....	
	.....	PO	0.545	100.0	0.545	96.7
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.560		0.545	100%	0.563	100%
Standard deviation	0.748		Relative SE: 0.738		Absolute SE: 0.750	
Coef_G relative	0.51					
Coef_G absolute	0.50					

Grand mean for levels used: 5.511  
 Variance error of the mean for levels used: 0.028  
 Standard error of the grand mean: 0.168

**Appendix C15**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 16 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.362		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.111	15.4
	.....	PI	.....		.....	
	.....	PO	0.608	100.0	0.608	84.6
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.362		0.608	100%	0.718	100%
Standard deviation	0.602		Relative SE: 0.780		Absolute SE: 0.848	
Coef_G relative	0.37					
Coef_G absolute	0.33					

Grand mean for levels used: 5.296  
 Variance error of the mean for levels used: 0.119  
 Standard error of the grand mean: 0.345

**Appendix C16**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.497		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.423	43.4
	.....	PI	.....		.....	
	.....	PO	0.553	100.0	0.553	56.6
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.497		0.553	100%	0.976	100%
Standard deviation	0.705		Relative SE: 0.744		Absolute SE: 0.988	
Coef_G relative	0.47					
Coef_G absolute	0.34					

Grand mean for levels used: 4.845  
 Variance error of the mean for levels used: 0.432  
 Standard error of the grand mean: 0.657

**Appendix C17**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.578		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.088	13.2
	.....	PI	.....		.....	
	.....	PO	0.575	100.0	0.575	86.8
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.578		0.575	100%	0.663	100%
Standard deviation	0.760		Relative SE: 0.758		Absolute SE: 0.814	
Coef_G relative	0.50					
Coef_G absolute	0.47					

Grand mean for levels used: 5.273  
 Variance error of the mean for levels used: 0.098  
 Standard error of the grand mean: 0.312

**Appendix C18**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 19 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.086		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.513	46.1
	.....	PI	.....		.....	
	.....	PO	0.600	100.0	0.600	53.9
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.086		0.600	100%	1.112	100%
Standard deviation	0.293		Relative SE: 0.774		Absolute SE: 1.055	
Coef_G relative	0.12					
Coef_G absolute	0.07					

Grand mean for levels used: 5.043  
 Variance error of the mean for levels used: 0.518  
 Standard error of the grand mean: 0.720

**Appendix C19**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 20 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.641		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.035	7.2
	.....	PI	.....		.....	
	.....	PO	0.450	100.0	0.450	92.8
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.641		0.450	100%	0.485	100%
Standard deviation	0.801		Relative SE: 0.671		Absolute SE: 0.696	
Coef_G relative	0.59					
Coef_G absolute	0.57					

Grand mean for levels used: 5.029  
 Variance error of the mean for levels used: 0.044  
 Standard error of the grand mean: 0.211

**Appendix C20**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.795		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.157	20.0
	.....	PI	.....		.....	
	.....	PO	0.631	100.0	0.631	80.0
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.795		0.631	100%	0.788	100%
Standard deviation	0.892		Relative SE: 0.794		Absolute SE: 0.888	
Coef_G relative	0.56					
Coef_G absolute	0.50					

Grand mean for levels used: 5.112  
 Variance error of the mean for levels used: 0.170  
 Standard error of the grand mean: 0.412

**Appendix C21**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.573		.....		.....	
	.....	I	.....		.....	
	.....	O	.....		0.018	3.6
	.....	PI	.....		.....	
	.....	PO	0.490	100.0	0.490	96.4
	.....	IO	.....		.....	
	.....	PIO	.....		.....	
Sum of variances	0.573		0.490	100%	0.509	100%
Standard deviation	0.757		Relative SE: 0.700		Absolute SE: 0.713	
Coef_G relative	0.54					
Coef_G absolute	0.53					

Grand mean for levels used: 5.474  
 Variance error of the mean for levels used: 0.028  
 Standard error of the grand mean: 0.166

**Appendix C22 – 29 (D Study)**

Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	4
Occasion	O	3	INF	

G Study Table  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.225		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.039	54.6
	.....	PI	0.001	2.5	0.001	1.1
	.....	PO	0.030	93.2	0.030	41.8
	.....	IO	.....		0.000	0.5
	.....	PIO	0.001	4.3	0.001	1.9
Sum of variances	0.225		0.032	100%	0.071	100%
Standard deviation	0.474		Relative SE: 0.179		Absolute SE: 0.267	
Coef_G relative	0.88					
Coef_G absolute	0.76					

Grand mean for levels used: 5.167  
 Variance error of the mean for levels used: 0.042  
 Standard error of the grand mean: 0.204

**Appendix C23-D Study**  
**Observation and Estimation Designs**

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	4 11
Occasion	O	3	INF	

**G Study Table**  
**(Measurement design P/IO)**

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.237		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.038	51.9
	.....	PI	0.002	5.1	0.002	2.4
	.....	PO	0.030	86.6	0.030	40.8
	.....	IO	.....		0.001	0.9
	.....	PIO	0.003	8.3	0.003	3.9
Sum of variances	0.237		0.035	100%	0.073	100%
Standard deviation	0.487		Relative SE: 0.186		Absolute SE: 0.271	
Coef_G relative	0.87					
Coef_G absolute	0.76					

Grand mean for levels used: 5.172  
 Variance error of the mean for levels used: 0.041  
 Standard error of the grand mean: 0.203

**Appendix C24-D Study**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	4 9 11
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.248		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.027	41.5
	.....	PI	0.003	7.8	0.003	4.4
	.....	PO	0.030	80.1	0.030	45.6
	.....	IO	.....		0.001	1.6
	.....	PIO	0.005	12.1	0.005	6.9
Sum of variances	0.248		0.037	100%	0.066	100%
Standard deviation	0.498		Relative SE: 0.194		Absolute SE: 0.256	
Coef_G relative	0.87					
Coef_G absolute	0.79					

Grand mean for levels used: 5.186  
 Variance error of the mean for levels used: 0.031  
 Standard error of the grand mean: 0.175

**Appendix C25-D Study**  
Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	4 9 11 18
Occasion	O	3	INF	

**G Study Table**  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.264		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.028	40.3
	.....	PI	0.004	10.5	0.004	6.1
	.....	PO	0.030	73.8	0.030	42.9
	.....	IO	.....		0.001	1.7
	.....	PIO	0.006	15.6	0.006	9.1
Sum of variances	0.264		0.041	100%	0.070	100%
Standard deviation	0.514		Relative SE: 0.202		Absolute SE: 0.264	
Coef_G relative	0.87					
Coef_G absolute	0.79					

Grand mean for levels used: 5.194  
 Variance error of the mean for levels used: 0.032  
 Standard error of the grand mean: 0.179

**Appendix C26-D Study**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	2 4 9 11 18
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.276		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.018	28.9
	.....	PI	0.006	13.7	0.006	9.4
	.....	PO	0.029	66.7	0.029	46.0
	.....	IO	.....		0.001	2.2
	.....	PIO	0.008	19.6	0.008	13.5
Sum of variances	0.276		0.043	100%	0.062	100%
Standard deviation	0.525		Relative SE: 0.207		Absolute SE: 0.250	
Coef_G relative	0.87					
Coef_G absolute	0.82					

Grand mean for levels used: 5.220  
 Variance error of the mean for levels used: 0.022  
 Standard error of the grand mean: 0.149

**Appendix C27-D Study**  
**Observation and Estimation Designs**

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	2 4 8 9 11 18
Occasion	O	3	INF	

**G Study Table**  
**(Measurement design P/IO)**

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.279		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.023	30.9
	.....	PI	0.008	15.6	0.008	10.5
	.....	PO	0.032	63.2	0.032	42.3
	.....	IO	.....		0.002	2.1
	.....	PIO	0.011	21.2	0.011	14.2
Sum of variances	0.279		0.050	100%	0.075	100%
Standard deviation	0.528		Relative SE: 0.224		Absolute SE: 0.274	
Coef_G relative	0.85					
Coef_G absolute	0.79					

Grand mean for levels used: 5.212  
 Variance error of the mean for levels used: 0.028  
 Standard error of the grand mean: 0.166

**Appendix C28-D Study**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	2 3 5 6 7 9 10 12 13 15 16 18 19 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.191		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.017	11.7
	.....	PI	0.022	20.4	0.022	15.4
	.....	PO	0.027	24.8	0.027	18.8
	.....	IO	.....		0.018	12.5
	.....	PIO	0.059	54.9	0.059	41.6
Sum of variances	0.191		0.108	100%	0.143	100%
Standard deviation	0.436		Relative SE: 0.329		Absolute SE: 0.378	
Coef_G relative	0.64					
Coef_G absolute	0.57					

Grand mean for levels used: 5.238  
 Variance error of the mean for levels used: 0.037  
 Standard error of the grand mean: 0.192

**Appendix C29-D Study**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	2 3 5 6 7 9 10 12 13 15 16 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.174		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.004	2.9
	.....	PI	0.021	18.9	0.021	15.0
	.....	PO	0.016	14.1	0.016	11.2
	.....	IO	.....		0.025	17.5
	.....	PIO	0.075	67.0	0.075	53.3
Sum of variances	0.174		0.112	100%	0.140	100%
Standard deviation	0.417		Relative SE: 0.334		Absolute SE: 0.374	
Coef_G relative	0.61					
Coef_G absolute	0.55					

Grand mean for levels used: 5.259  
 Variance error of the mean for levels used: 0.031  
 Standard error of the grand mean: 0.176

**Appendix C30 – 32 (D Study-Autonomy)**

Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 5 6 7 9 10 12 13 15 16 18 19 20 21
Occasion	O	3	INF	

G Study Table  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.186		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.041	21.3
	.....	PI	0.018	14.2	0.018	9.1
	.....	PO	0.006	4.9	0.006	3.1
	.....	IO	.....		0.029	14.7
	.....	PIO	0.100	80.9	0.100	51.8
Sum of variances	0.186		0.124	100%	0.194	100%
Standard deviation	0.431		Relative SE: 0.352		Absolute SE: 0.440	
Coef_G relative	0.60					
Coef_G absolute	0.49					

Grand mean for levels used: 5.248  
 Variance error of the mean for levels used: 0.072  
 Standard error of the grand mean: 0.269

**Appendix C31-D Study-Autonomy**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 5 6 7 9 10 12 13 14 15 16 18 19 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.093		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.042	15.7
	.....	PI	0.029	16.3	0.029	10.8
	.....	PO	0.014	8.1	0.014	5.3
	.....	IO	.....		0.048	18.0
	.....	PIO	0.135	75.6	0.135	50.1
Sum of variances	0.093		0.178	100%	0.269	100%
Standard deviation	0.306		Relative SE: 0.422		Absolute SE: 0.518	
Coef_G relative	0.34					
Coef_G absolute	0.26					

Grand mean for levels used: 5.182  
 Variance error of the mean for levels used: 0.093  
 Standard error of the grand mean: 0.305

**Appendix C32-D Study -Autonomy**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 5 6 7 9 10 12 13 14 15 16 17 18 19 20 21
Occasion	O	3	INF	

G Study Table  
 (Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.094		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.002	0.6
	.....	PI	0.004	1.7	0.004	1.2
	.....	PO	0.010	4.7	0.010	3.2
	.....	IO	.....		0.099	31.9
	.....	PIO	0.196	93.6	0.196	63.2
Sum of variances	0.094		0.210	100%	0.311	100%
Standard deviation	0.307		Relative SE: 0.458		Absolute SE: 0.557	
Coef_G relative	0.31					
Coef_G absolute	0.23					

Grand mean for levels used: 5.152  
 Variance error of the mean for levels used: 0.103  
 Standard error of the grand mean: 0.322

**Appendix C33 – 36 (D Study-Competence)**

Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 4 6 7 8 9 11 12 14 16 17 18 20 21
Occasion	O	3	INF	

G Study Table  
(Measurement design P/IO)

Source of variance	Differ-entiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.219		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		(0.000)	0.0
	.....	PI	0.061	37.6	0.061	34.9
	.....	PO	0.039	24.1	0.039	22.4
	.....	IO	.....		0.012	7.1
	.....	PIO	0.063	38.3	0.063	35.6
Sum of variances	0.219		0.164	100%	0.176	100%
Standard deviation	0.468		Relative SE: 0.404		Absolute SE: 0.419	
Coef_G relative	0.57					
Coef_G absolute	0.55					

Grand mean for levels used: 5.178  
 Variance error of the mean for levels used: 0.016  
 Standard error of the grand mean: 0.125

**Appendix C34-D Study-Competence**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 6 7 8 9 11 12 14 16 17 18 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.207		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		(0.000)	0.0
	.....	PI	0.075	37.8	0.075	34.8
	.....	PO	0.040	20.4	0.040	18.8
	.....	IO	.....		0.017	8.0
	.....	PIO	0.083	41.8	0.083	38.5
Sum of variances	0.207		0.198	100%	0.215	100%
Standard deviation	0.455		Relative SE: 0.444		Absolute SE: 0.463	
Coef_G relative	0.51					
Coef_G absolute	0.49					

Grand mean for levels used: 5.163  
 Variance error of the mean for levels used: 0.021  
 Standard error of the grand mean: 0.143

**Appendix C35-D Study-Competence**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 6 7 8 9 10 11 12 14 16 17 18 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.174		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.005	1.8
	.....	PI	0.096	39.3	0.096	35.9
	.....	PO	0.032	13.1	0.032	11.9
	.....	IO	.....		0.018	6.8
	.....	PIO	0.116	47.7	0.116	43.5
Sum of variances	0.174		0.243	100%	0.266	100%
Standard deviation	0.418		Relative SE: 0.493		Absolute SE: 0.516	
Coef_G relative	0.42					
Coef_G absolute	0.40					

Grand mean for levels used: 5.118  
 Variance error of the mean for levels used: 0.027  
 Standard error of the grand mean: 0.163

**Appendix C36-D Study-Competence**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 2 3 4 5 6 7 8 9 10 11 12 14 16 17 18 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.221		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		(0.000)	0.0
	.....	PI	0.104	34.3	0.104	30.7
	.....	PO	0.035	11.4	0.035	10.2
	.....	IO	.....		0.035	10.3
	.....	PIO	0.165	54.4	0.165	48.8
Sum of variances	0.221		0.304	100%	0.339	100%
Standard deviation	0.470		Relative SE: 0.551		Absolute SE: 0.582	
Coef_G relative	0.42					
Coef_G absolute	0.39					

Grand mean for levels used: 5.190  
 Variance error of the mean for levels used: 0.040  
 Standard error of the grand mean: 0.199

**Appendix C37 – 42 (D Study-Relatedness)**

Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 8 10 11 13 14 15 17 19 20
Occasion	O	3	INF	

G Study Table  
(Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.172		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.111	50.2
	.....	PI	0.024	24.2	0.024	10.7
	.....	PO	0.028	29.0	0.028	12.8
	.....	IO	.....		0.013	5.7
	.....	PIO	0.046	46.8	0.046	20.6
Sum of variances	0.172		0.097	100%	0.221	100%
Standard deviation	0.415		Relative SE: 0.312		Absolute SE: 0.470	
Coef_G relative	0.64					
Coef_G absolute	0.44					

Grand mean for levels used: 5.080  
 Variance error of the mean for levels used: 0.126  
 Standard error of the grand mean: 0.355

**Appendix C38-D Study-Relatedness**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 8 10 11 13 14 15 17 19 20
Occasion	O	3	INF	

G Study Table  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.149		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.107	44.9
	.....	PI	0.026	22.9	0.026	10.9
	.....	PO	0.031	27.4	0.031	13.0
	.....	IO	.....		0.018	7.6
	.....	PIO	0.056	49.7	0.056	23.6
Sum of variances	0.149		0.113	100%	0.239	100%
Standard deviation	0.386		Relative SE: 0.337		Absolute SE: 0.489	
Coef_G relative	0.57					
Coef_G absolute	0.38					

Grand mean for levels used: 5.057  
 Variance error of the mean for levels used: 0.128  
 Standard error of the grand mean: 0.358

**Appendix C39-D Study-Relatedness**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 8 10 11 12 13 14 15 17 19 20
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.152		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.158	50.1
	.....	PI	0.025	18.8	0.025	8.1
	.....	PO	0.040	29.5	0.040	12.7
	.....	IO	.....		0.022	7.0
	.....	PIO	0.070	51.7	0.070	22.2
Sum of variances	0.152		0.136	100%	0.316	100%
Standard deviation	0.390		Relative SE: 0.368		Absolute SE: 0.562	
Coef_G relative	0.53					
Coef_G absolute	0.33					

Grand mean for levels used: 5.062  
 Variance error of the mean for levels used: 0.183  
 Standard error of the grand mean: 0.427

**Appendix C40-D Study-Relatedness**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 8 10 11 12 13 14 15 17 19 20 21
Occasion	O	3	INF	

G Study Table  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.111		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.198	50.2
	.....	PI	0.032	19.4	0.032	8.1
	.....	PO	0.040	24.5	0.040	10.2
	.....	IO	.....		0.032	8.0
	.....	PIO	0.092	56.1	0.092	23.4
Sum of variances	0.111		0.165	100%	0.395	100%
Standard deviation	0.333		Relative SE: 0.406		Absolute SE: 0.629	
Coef_G relative	0.40					
Coef_G absolute	0.22					

Grand mean for levels used: 4.980  
 Variance error of the mean for levels used: 0.233  
 Standard error of the grand mean: 0.482

**Appendix C41-D Study-Relatedness**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 7 8 10 11 12 13 14 15 17 19 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	0.072		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.268	53.4
	.....	PI	0.034	18.0	0.034	6.7
	.....	PO	0.030	16.3	0.030	6.1
	.....	IO	.....		0.047	9.4
	.....	PIO	0.123	65.7	0.123	24.4
Sum of variances	0.072		0.187	100%	0.502	100%
Standard deviation	0.269		Relative SE: 0.432		Absolute SE: 0.708	
Coef_G relative	0.28					
Coef_G absolute	0.13					

Grand mean for levels used: 4.897  
 Variance error of the mean for levels used: 0.317  
 Standard error of the grand mean: 0.563

**Appendix C42-D Study-Relatedness**  
 Observation and Estimation Designs

Facet	Label	Levels	Univ.	Reduction (levels to exclude)
Person	P	116	INF	
Item	I	21	21	1 3 4 5 6 7 8 10 11 12 13 14 15 16 17 19 20 21
Occasion	O	3	INF	

**G Study Table**  
 (Measurement design P/IO)

Source of variance	Differentiation variance	Source of variance	Relative error variance	% relative	Absolute error variance	% absolute
P	(0.000)		.....		.....	
	.....	I	.....		(0.000)	0.0
	.....	O	.....		0.204	36.5
	.....	PI	0.048	18.1	0.048	8.5
	.....	PO	0.044	16.9	0.044	7.9
	.....	IO	.....		0.092	16.4
	.....	PIO	0.172	65.0	0.172	30.6
Sum of variances	0.000		0.264	100%	0.560	100%
Standard deviation	0.000		Relative SE: 0.514		Absolute SE: 0.748	
Coef_G relative	0.00					
Coef_G absolute	0.00					

Grand mean for levels used: 4.914  
 Variance error of the mean for levels used: 0.299  
 Standard error of the grand mean: 0.547