efpsa Journal of European Psychology Students

McMurtrie, B. (2023). Investigating the dimensions of mind perception. *Journal of European Psychology Students, 14*(1), 54–68. https://doi.org/10.59477/jeps.594.

RESEARCH ARTICLE

Investigating the Dimensions of Mind Perception

Brandon McMurtrie[1]

Mind perception is the ability to infer the presence of a mind in other beings or non-living things (e.g., a tree, an animal, a robot) and make judgements about what "kind" of mind that being possesses. Research has shown that there is a dimensionality to the schema of mind perception, though the number of dimensions is debated. The present study aimed to explore the dimensions via a mind perception scale that measures participants' perceptions of mental capacities (n = 181). The data was highly suited for factor analysis, so principal axis factoring and multiple criteria were used to find the retained factors. Findings suggest a two-dimensional model of mind perception, supporting the field's landmark study by Gray et al. (2007).

Keywords: mind perception, theory of mind, factor analysis, principal component analysis

Mind perception refers to the ability to perceive a mind in other beings or non-living agents (Waits et al., 2010). It allows individuals to perceive things in their environment as "minded" and to identify other potentially conscious beings. This allows one to engage in the practice of theorising about the contents of those minds: what Baron-Cohen et al. (1985) called a "theory of mind", and Frith and Frith (2003) called "mentalising". Mentalising enables one to better navigate a dynamic world populated by other dynamic beings. It involves the practice of simulating what others may be thinking: "Can they see me? What do they want? Do they like me? Can they tell that I am lying?". The advantages of the ability to theorise in this manner are readily apparent and it all starts with mind perception—the ability to perceive the presence of a mind in the first place and to identify how "much" mind or what "kind" of mind the being has. These mind perceptions then direct our theories about the contents of a given mind at the moment.

The instinct to use mind perception to detect 'minded' beings in our environment is first displayed in infancy as the tendency to attend with a greater focus to biological motion, self-propelled objects, and objects that appear to have a face (Johnson, 2000). At around two years old children begin to mentalise, interpreting others' actions in terms of underlying mental states (Epley & Waytz, 2010). This mentalising relies on mind perception inferences: the perception of a mind and a qualitative judgement of that mind (Epley & Waytz). Mind perception and mentalising occur through two primary methods for theorising about other minds: simulation theories and theory-theories (Epley & Waytz). Simulation theories are based on egocentric reasoning about the nature of other minds from an awareness of one's own mind. Theory-theories are based on acquired cognitions, schemas, and intuitions about how other beings think and behave. The egocentric simulation theories of mind form the basis of mind perception in childhood when children have primarily only their own mind by which to model the minds of others. We come to rely on theory-theories of mind as development continues—based on learning through interaction and observing how other beings appear to think and behave (Epley & Waytz).

The study of mind perception touches on a broad

1 Department of Psychology, Massey University, New Zealand.
Corresponding author: Brandon McMurtrie (B.McMurtrie@massey.ac.nz)

array of poignant socio-psychological phenomena. Mind perception likely underpins our conceptions of morality: the judgement and classification of moral behaviours are dependent on the observers' judgements of the minds of the parties involved (Gray et al., 2012). People with a greater need to connect with others are more likely to perceive a mind in nonhuman or even non-living agents (Epley & Waytz, 2010). Furthermore, people are more likely to deny the presence of a mind in outgroup members (Haslam & Loughnan, 2014), and mind perceptions feature heavily in rationalisations involved in animal welfare, meat-eating, and vegetarianism (Bastian et al., 2012; Loughnan et al., 2014). Understanding mind perception and its influence on behaviour can therefore provide insights into tribalistic behaviour, morality, dehumanisation, animal rights, and even artificial intelligence (e.g., Gray & Wegner, 2012; Lee et al., 2019; Malle, 2019; Wang & Krum Huber, 2018).

The Dimensions of Mind Perception

Mind perception can be thought of as a shared cognitive schema or a shared cultural model (Ben-Zeev, 1988; d'Andrade, 1987) that is incorporated into the process of perceiving others, influencing and constraining one's judgements of others' mental capacities. What form does the cognitive schema take? Does it limit our conception of other minds to a simple unidimensional model so that we perceive others as having simply 'more' or 'less' mind, or is there a dimensionality to the mind perception schema?

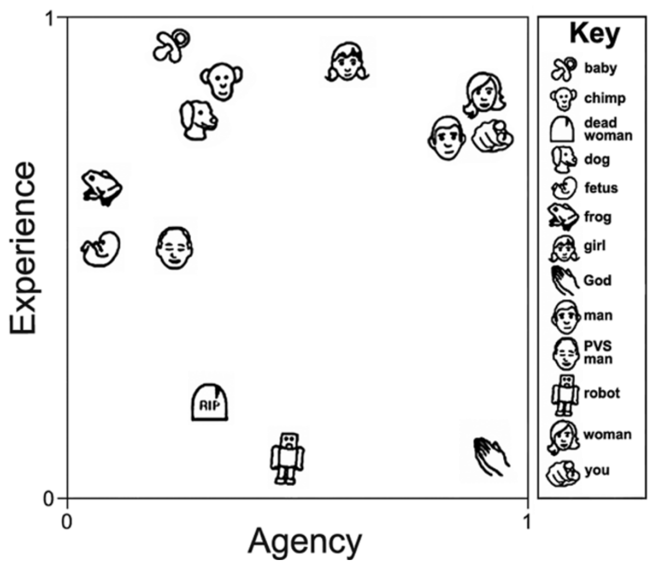
Initially, the potential for an underlying dimensionality of mind perception (i.e., of the cognitive schema of mind perception) was not considered. Research operated under the folk-psychology assumption that it was unidimensional, and that people perceived other beings as having, simply, more or less mind (Gray et al., 2007). This folk-psychological model of mind perception assumed that people perceived the capacities of minds on a single sliding scale: that "higher order" capacities were inferred only in the presence of "lower order" capacities. For example, it was assumed that if a person perceives a being as able to calculate, plan and analyse (higher order capacities), then they must also perceive the being as able to feel pleasure and pain (lower order capacities).

The pioneering work by Gray et al. (2007) was the first to investigate the potential for dimensionality underlying the perception of other minds. They asked participants to rate the degree to which they thought a range of different characters were capable of various mental capacities and then subjected these ratings to a dimension reduction technique. They found two dimensions underlying people's perceptions of a mind. Capacities related to affect and emotion (e.g., fear, anger, hunger) loaded on one dimension, and capacities related to conscious and directed action (e.g., planning, self-control, memory) loaded on another. They labelled these dimensions Experience and Agency, respectively. Agency refers to the capacity to choose and act, while Experience refers to the capacity to feel and experience various affective mental states, such as fear, hunger, happiness, or pleasure. For example, participants perceived an adult human to be fully capable of both Agency and Experience. Human infants were perceived as having a high capacity for Experience, but a low capacity for Agency (see Figure 1). Dogs were perceived to have high Experience (slightly lower than a human infant) and moderate Agency (slightly more than the infant). Artificial minds (e.g., robots, artificial intelligence (AI)) were seen to be moderately high in Agency, but low in Experience. Gray et al. (2007) therefore provided evidence for the existence of a schema of mind perception in which mental capacities are perceived to comprise two meaningfully distinct dimensions: Agency and Experience.

Supporting the validity of a two-dimensional model of mind perception, Gray et al. (2011) found associations between mind perception variations and personality, autism, psychopathy, and schizotypal disorders. They found that higher scores on an autism scale were associated with lower perceptions of Agency in others. Higher scores on a measure of schizotypy were associated with a tendency to indiscriminately perceive minds, resulting in higher ratings of both dimensions. Higher scores on a measure of psychopathy were associated with lower perceptions of Experience in other beings. These findings were consistent with the current understanding of the cognitive distortions of autism, schizotypy, and psychopathy. The associations between mind perception ratings and psychopathology were replicated by Tharp et al. (2016), who also found that some Big Five personality traits were relevant to mind perception tendencies. Their findings revealed that agreeableness was associated with higher perceptions of Agency but was not associated with perceptions of Experience. Furthermore, Buck et al. (2017) found that people experiencing paranoia tend to perceive more mind in non-human objects or dead people.

Figure 1

The Plot of Character Scores Along the Two Dimensions of Mind Perception (Agency and Experience) from Gray et al. (2007).



These studies suggested that our mental representations of other minds likely do not occur along a singular dimension of higher or lower-order capacities. Instead, there are groups of related capacities that can vary somewhat independently of each other. These groups of capacities are the dimensions of mind perception, and they appear to constitute a shared cognitive schema of the way minds are constructed. The study of the dimensionality of mind perception, started by Gray et al. (2007), is, therefore, an attempt to develop a measure that accurately portrays the cognitive schema that guides people's judgements and classifications of other minds.

Methodological Issues in Gray et al. (2007) Perception

Unfortunately, despite the novelty of the research, Gray et al. (2007) did not actually find a clean dimensional structure (Table 1). Six of their 18 items loaded equally on both dimensions, and most of the other items cross-loaded onto the other dimension. Cross-loadings above .3 are generally considered problematic in factor analysis (Costello & Osborne, 2005). Only one item on each of the dimensions displayed a clean loading on its primary dimension, with no cross-loading (hunger on Experience, self-control on Agency). Replications of this Agency-Experience model have shown a cleaner factor structure than the one found initially by Gray et al. (2007), but there is always some non-trivial level of errant loadings (Willard & MacNamara, 2019).

Table 1

Loading Matrix of the 18 Mental Capacities by Gray et al. (2007)

	Factor	
Mental Capacity	Experience	Agency
Hunger	.98	.15
Fear	.93	.31
Pain	.89	.42
Pleasure	.85	.51
Rage	.78	.59
Desire	.76	.64
Joy	.68	.61
Personality	.72	.68
Consciousness	.71	.69
Pride	.71	.69
Embarrassment	.70	.65

	Factor	
Mental Capacity	Experience	Agency
Thought	.68	.73
Communication	.66	.74
Planning	.55	.82
Emotion recognition	.54	.83
Morality	.36	.93
Memory	.33	.91
Self-Control	.18	.97

Perhaps more problematic for Gray et al.'s (2007) pioneering Agency-Experience model are the methodological issues as to how the dimensions were determined. Though many refer to Gray et al. (2007) as having used a principal components analysis, they described their analysis as a "principal components factor analysis (varimax rotation)" (p. 619). It is unclear whether the authors are making a common mistake in psychological literature by conflating principal components analysis with factor analysis, or if they are employing a principal axis method of factor extraction, also known as principal components factor analysis (Bryant & Yarnold, 1995).

Principal Components and Factor Analysis

Principal components analysis and factor analysis are often incorrectly lumped together and used interchangeably. However, principal components analysis is a dimension reduction technique, while factor analysis is a theoretically driven analysis that is used to model hypothesised latent variables. The difference between principal components analysis and factor analysis lies in their assumptions and is perhaps most intuitively described by imagining a direction in the analysis.

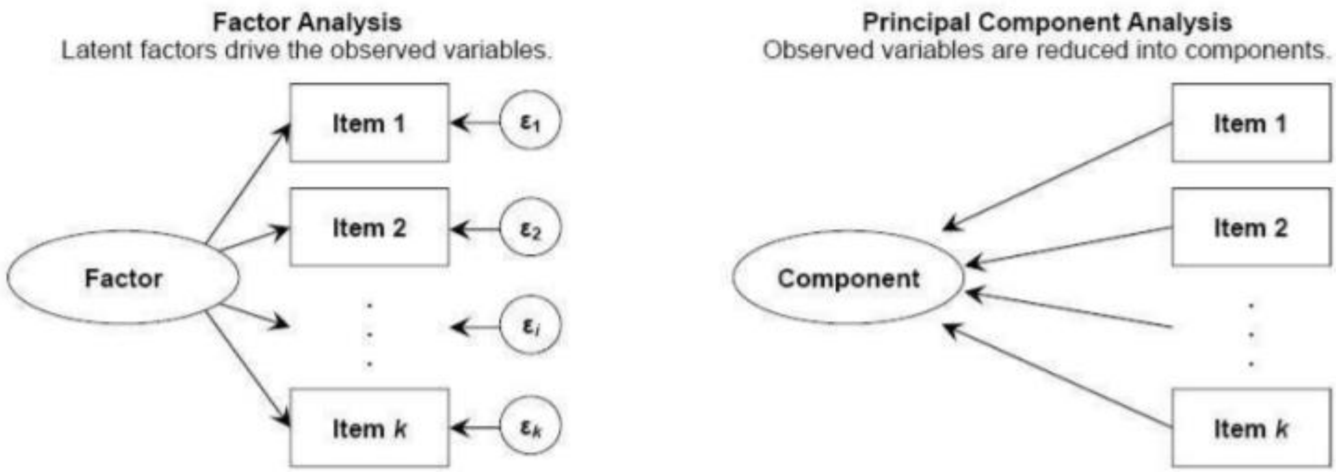
Principal components analysis starts from the data, attempting to summarise observed data and producing components as weighted linear combinations of observed variables (Figure 2). Principal components analysis assumes that variables are measured with perfect reliability, leaving values of 1.0 on the diagonal of the correlation matrix (Borgatta et al., 1986). Therefore, components are intended to explain as much of the total variation in the data as possible (Bryant & Yarnold, 1995).

In contrast, factor analysis assumes the presence of latent factors that produce the observed data (Figure 2). Factor analysis is a method of modelling these factors and explaining patterns of covariation among variables as functions of these latent factors (Osborne & Banjanovic, 2016). Factor analysis does not assume perfect reliability but uses an iterative procedure to place communality estimates (e.g., the multiple R^2) along the diagonal of the correlation matrix (i.e., values less than 1.0, resulting in a reduced correlation matrix), thereby attempting to account for measurement error (Borgatta et al., 1986). Factor analysis discriminates between three types of variances: common variance, unique variance, and measurement error. Factors in this analysis seek to explain common variance only.

Therefore, factor analysis is more accurate and appropriate for finding which variables group together (i.e., have a lot of common variance) and that may be explained by an underlying construct (Bryant & Yarnold, 1995). If certain variables are seen to covary with one another, the factors in a factor analysis can explain these patterns of covariation without assuming perfect measurement. If the variables load onto a single factor without cross-loading onto other factors (i.e., if a simple structure is found), then this supports the hypothesis that the modelled latent factors drive patterns seen in the data (Osborne, 2014). While it is true that sometimes principal components analysis and factor analysis converge on a similar solution, this is not always the case and should not be taken as evidence of their equivalence. The assumptions of principal components analysis show that it should not be used to infer the presence of latent variables, rather it should be used only as a dimension reduction technique (Borgatta et al., 1986). As Widman (1993) clearly states, principal components analysis "should not be used if a researcher wishes to obtain parameters reflecting latent constructs or factors" (p.

Figure 2

A Conceptual View of Factor Analysis by Matsunaga (2010)



263).

Mind perception is presently conceived as a latent "cognitive structure" in the form of a shared cognitive schema through which humans perceive and categorise other minds (D'andrade, 1987; Malle, 2021). This aligns with the definition of latent constructs as 'hypothetical constructs' that may or may not be "real" (i.e., they cannot be directly measured or seen, e.g., self-esteem, introversion), but represent mental constructs or tendencies, that drive empirical phenomena. In this view, the mind perception cognitive schema is a latent construct that influences how participants perceive and categorise other minds. In asking a participant to consciously rate other minds along a range of capacities, we can think of these ratings and their covariances as caused and constrained by the schema of mind perception. These explicit ratings made by participants are indirect measures of mind perception and are likely subject to error. They may not perfectly reflect the latent mind perceptions, as survey measures such as this are prone to capturing error (Saris & Revilla, 2016). Therefore, given that we view the ratings of capacities as caused by the latent construct of mind perception, and that mind perception ratings are indirect measures that likely contain random error, we have a model that aligns with the proper use of factor analysis (see Figure 2). For this reason, we assert that factor analysis is the more appropriate method for this research.

Measures of Mind Perceptions

Although no real item analysis has been performed on the items used by Gray et al. (2007), many researchers have moved ahead with the model and used the items as a measure of mind perception. This is problematic for two reasons: the first is that, as Weisman et al. (2017) and Malle (2019) noted, the initial questionnaire that was used to produce the Agency-Experience model under-sampled the domain of mental capacities. There were a small handful of vague and semantically related words used to measure a construct that pertains to a range of different mental capacities and processes. Secondly, the mind perception questionnaires (usually referred to collectively as the Mind Survey, despite there being no single questionnaire) used throughout the literature vary widely and are often short. In some studies, the full 18 items were used (Willard & Macnamara, 2019), others used six (Gray, et al., 2011), some used two (Gray & Wegner, 2012) and some used three items from each dimension to produce an indexed mind perception score (Buck et. al., 2017; Gray et. al., 2011). Not only is it likely that the initial questionnaire by Gray et al. (2007) has low content validity, but it has also not been subjected to any validation studies. The validity of using these disparate forms of the questionnaire, which often differ in length and constitution, has never been investigated. This calls into question the accuracy of the studies on the effects and influences of mind perception.

Therefore, although it has admittedly found some practical use and provided insight into mind perception, as described in some of the research reviewed above, the two-dimensional model found by Gray et al. (2007) and expanded on by others is plagued by methodological issues and might be leaving out some important insights.

Other Models and Measures of Mind Perceptions

Four experiments by Weisman et al. (2017) attempted to address the perceived low content validity in Gray et al.'s (2007) initial Mind Survey. They used a much larger pool of items pertaining to agentic, emotional, cognitive, perceptual, physiological, and social mental capacities in order to ensure the entire domain of mental capacities was sampled. Using exploratory factor analysis, they found a three-factor model of mind perception, labelled Body, Heart, and Mind. This was an advancement of the study of mind perception and had a more valid methodology. However, upon close inspection, the factors had a somewhat irregular, problematic composition. For example, the Mind factor contained high-loading items pertaining to higher-order thinking capacities (communication, goal-driven behaviour, reasoning, and memory) but also basic perception (odour detection, depth perception, sight, and hearing). The Body factor contained high-loading items such as hunger, pleasure, and fear, but also items pertaining to computations and free will (Weisman et al., 2017). The factor structure also contained a large number of cross-loadings.

In a series of recent studies, Malle (2019) sought to improve and refine the questionnaire by expanding and altering the item pools of the previous studies. They removed the undifferentiated items from Gray et al. (2007) and expanded item categories pertaining to physiological, affective, cognitive, and agentic capacities from Weisman et al. (2017). Using a 28 and 38-item questionnaire in two separate studies, Malle found a clearer three-dimensional structure of mind perception using principal components analysis. The three dimensions were labelled Mental and Moral Regulation, Affect, and Reality Interaction.

Based on the items that compose these three dimensions, it appears that Malle's (2019) study retained the Experience dimension from Gray et al. (2007) in the Affect dimension, and separated the original Agency dimension into the Mental and Moral Regulation, and Reality Interaction dimensions. However, it retained these dimensions not by using single-word items that are overly related semantically. The Affect dimension contains emotion (love, anger) and biological and sensory-related affective states (hunger, sexual arousal, taste). The Mental and Moral regulation dimension contains cognitive-based items of varying types and structures. The items include a range of processes such as understanding oneself (providing reasons for one's actions), understanding others (inferring what a person is thinking, understanding a person's goals), awareness of time and its relation to the effects of one's own actions (planning, self-control), and communication. Reality Interaction contains a mixture of items that pertain to basic stimuli response and basic directed action (moving, observing, sensing).

Although these studies addressed the content validity of the original mind perception studies, they had other problems. Both Weisman et al. (2017) and Malle (2019) had participants rate only one character. Factor analysis is used to find items that covary with one another and is not interested in the absolute value of ratings given on an item. Therefore, in studies such as these, it is more appropriate to have participants rate multiple different characters. The factor technique can then establish a pattern of covariation within each participant, and subject all these patterns to the analysis. It is not appropriate to ask a participant one question and expect that it perfectly reflects the underlying construct within that person.

Additionally, even though Malle (2019) produced what is perhaps the best questionnaire for measuring mind perceptions in terms of item choice and content validity, and whose results produced the cleanest dimensional structure, they used a principal components analysis which we have asserted here is not the most appropriate analysis for inferring latent variables.

The Present Study

A measure of mind perception can greatly enhance the field of social psychology in two primary ways. The first is by investigating how mind perceptions affect those being perceived. The way people perceive a human, animal, or other beings along the dimensions of mind perception is likely to be highly relevant to the way that being is treated, judged, or valued. Bastian et al. (2012) found that an animal's average edibility rating was negatively correlated with its mind perception ratings—they theorised that people only see fit to eat animals that they perceive to score "low" on the mind perception dimensions. Gray and Wegner (2012) found that the way people perceived a robot along the dimensions of mind perception was relevant to whether that robot was "accepted" or elicited the uneasiness known as "the uncanny valley". Additionally, Gray et al. (2012) propose that mind perception is the essence of morality and mediates our judgements of guilt or innocence of others. While these studies all relied heavily on Gray et al.'s (2007) initial Agency-Experience measures that we have shown to be of questionable validity, they highlight some interesting ideas and provide exemplars of the first way in which mind perception may be relevant to psychology.

The second avenue for a valid measure of mind perception to be useful to psychology is in quantifying the perceptual tendencies of individuals. For example, it may be found that certain individuals tend to overperceive others' Agency, or perhaps an individual can be shown to perceive others to be low in Experience. With an accurate measure of mind perception, we could investigate mind perception tendencies as an individual characteristic, and investigate causes, correlates, and effects of these perceptual tendencies. Gray et al. (2011) found that people who rated higher on the subclinical schizoid personality scale tended to give others higher mind perception ratings and that people higher in psychopathic personality traits tended to underperceive the Experiential capacity of others. Buck et al. (2017) found a positive correlation between mind perception ratings and paranoia. Again, these studies also used measures which we have shown to be problematic, but they highlight the second important way that mind perception may be highly relevant to psychology.

Although the research on mind perception thus far has produced some fascinating results, there are issues that need to be addressed. Others have begun to correct the problems of item structure, wording, and content validity, but issues pertaining to data quality, dimensionality, and statistical analysis persist. We believe that the questionnaire developed by Malle (2019) is the most conceptually sound measure of mind perception and provides a more nuanced picture of the dimensions along which minds are perceived and categorised. However, the survey needs to be distributed to a new sample of participants who rate multiple characters, and the data needs to be subjected to a factor analysis with an explicit and open factor reduction method and selection criteria.

Therefore, we undertake an altered replication of Malle's (2019) study with the aim of clarifying the dimensionality of mind perception in the hopes of allowing subsequent researchers to refine a new measure of mind perception and perform confirmatory analyses. We administer a shortened version of Malle's second questionnaire, composed of the 25 highest-loading items, to a sample of Australian and New Zealand participants. Additionally, we use a slightly altered character pool from those used in Malle (2019) and Gray et al. (2007), which covers a range of character types (mammals, vertebrates, invertebrates, adults, children, AI, land and sea creatures). We then have participants rate all the characters and perform an exploratory factor analysis to better capture mind perception as a latent construct. We hypothesise that a three-factor structure will emerge, similar to the component structure seen in Malle (2019).

Methods

Participants

Guadagnoli and Velicer (1988) advise that factors composed of many variables (around ten) with low loadings (around .4) require a sample size of at least 150. Likewise, they state that this sample size is also adequate for interpreting factors composed of four or more variables with loadings above .6. Given that the three factors hypothesised in this study are to be measured using ten, ten, and five items, respectively, and considering that in the study upon which this is based all items showed high PCA loadings, a sample size of 150 or more is adequate.

Therefore, we did not use a specific stopping rule based on statistical power, rather data collection proceeded until the funding limit for the study was reached. This resulted in a final sample size of $n = 181$.

Participants were recruited from Prolific.co, a participant-recruitment website for online research. Participants over the age of 18 who are residents of New Zealand or Australia were given an opportunity to participate in the study. Any participants who did not consent to participate, did not finish the survey, or failed any of the attention checks were to be excluded from the analysis. No participants were excluded. There were also no missing data. The sample consisted of 181 participants. Age ranged from 18 to 60 years ($M = 24.6$, $SD = 7.58$). The sample was composed of 131 females, 44 males, and five nonbinary or genderqueer participants. One participant did not respond to the demographic questions.

Materials

The Mind Perception Questionnaire

The 25-item questionnaire was taken from Malle's (2019) Study 2. The original questionnaire was composed of 38 items. The dimension Affect contained 17 items, Mental and Moral Regulation had 16, and Reality Interaction had five. In the interest of survey length, we took only the highest ten loading items from Affect and Mental and Moral Regulation for the survey and kept all five items from Reality Interaction.

The questionnaire was composed of 25 ability-statement items with the character name inserted into the item (e.g., "A newborn baby can get angry." or "A computer can uphold moral values."). Participants rated their agreement or disagreement with the ability statement on an 8-point Likert-type scale: 0 (*definitely not true*), to 7, (*definitely true*).

Characters

The 12 characters rated were a newborn baby, a typical three-year-old, an adult, a person in a coma, a chimpanzee, a jellyfish, a robot, a computer, a rabbit, a seagull, a dolphin, and a deer. The characters were presented in random order. Many characters were taken from previous studies: a baby, a chimpanzee, a person in a coma, and a robot were used in Gray et al. (2007); a newborn baby, a three-year-old, an adult, a rabbit, a jellyfish, and a computer were used in Malle (2019). A deer, a dolphin, and a seagull were new additions.

These characters were chosen because they span the range of animal classes (mammals, birds, invertebrates), they provide a range of habitat and locomotion types (land, sea, air), and they cover a range of intelligence types and sensory modes (AI, natural intelligence, central nervous systems, simple nervous system). Additionally, these are all animals that should be of general common knowledge to Australasian participants—all characters except the chimpanzee are commonly found in Australia and New Zealand.

Attention Checks

Three attention check items asked participants to select a certain response item (e.g., please select '3'). These attention checks were placed within the item block of a newborn baby, a deer, and a dolphin.

Procedure

The study used a cross-sectional survey design. Eligible participants followed a link from Prolific to the survey hosted by Qualtrics. Participants were introduced to the design and intent of the survey and asked for consent. Those who did not consent were thanked and redirected back to Prolific.

Upon consenting, participants were asked their age and gender. Participants were given brief instructions and then rated their agreement with the 25 ability statements for each of the 12 characters. Character order was randomised—each beginning on a separate page of the survey. Upon completion, participants were given the researchers' contact information, were directed to resources regarding the research topic, were thanked for their time, and were directed back to Prolific, so their participation could be logged for remuneration. Participants were paid a small fee for their participation according to Prolific's recommended remuneration scale.

Statistical Analysis

We used the PROC FACTOR procedure in the SAS software to perform an exploratory factor analysis to analyse the covariance matrix of the 25 capacities. Though each participant rated a suite of characters, the character type was ignored in the analysis. It merely provides a source of meaningful variation that allows us to analyse the way in which the items covary with each other across different characters.

The KMO and Bartlett's tests were used to measure the suitability of the data for factor analysis (Williams et al., 2010). The KMO test estimates the proportion of variance in the variables that may be explained by underlying factors (Kaiser, 1970). Values of .5 or higher are considered adequate. Bartlett's test of sphericity tests the null hypothesis that the variables are unrelated and therefore not suitable for factor analysis (Bartlett, 1950). A significant ($p < .5$) result indicates suitability for factor analysis.

The first challenge in conducting an exploratory factor analysis is choosing the appropriate factor extraction method. Convention dictates that Principal Axis Factoring or Maximum Likelihood should be used. De Winter and Dodou (2012) showed that for simple factor structures Principal Axis Factoring outperformed Maximum Likelihood, which fails to converge on a solution due to Heywood cases considerably more often than Principal Axis Factoring. Maximum Likelihood has an advantage due to its ability to subject factor loadings and correlations to significance testing; however, this comes with the assumption of multivariate normality and relies on an adequate sampling scheme in order to be relevant or interpretable.

Therefore, we used Principal Axis Factoring as we were not interested in producing inferential statistics for the factor structure due to the exploratory nature of the study and the convenience sample. Tests of model fit and statistical significance are better studied in a confirmatory factor analysis in which the researcher specifies the model parameters in advance, based on the results of an exploratory factor analysis, and uses a larger sample. To perform a factor analysis using Principal Axis Factoring we set the prior communality estimates to the squared multiple correlation.

The second challenge in conducting an exploratory factor analysis is choosing the number of factors to retain. No single criterion should be used to choose relevant factors, rather multiple criteria must be considered to settle on a solution; this is an exploratory method involving the researcher's subjectivity (Williams et al., 2010). We used the scree test (Cattell, 1966), the K1 rule (keeping factors with an eigenvalue > 1; Kaiser, 1960), the explained variance criterion (keeping factors with > 5% explained variance), and parallel analysis (O'Connor, 2000) to decide on the number of factors to retain.

The third challenge in conducting an exploratory factor analysis is choosing the type of rotation to apply. There are two categories of rotation: orthogonal and oblique. Orthogonal rotations are rarely appropriate in psychology, as they force the factor axes to remain uncorrelated. It is recommended to allow some correlation between axes in factor analyses in most studies in psychology (Osborne, 2014). In the present study, it is highly likely that there is some non-trivial correlation between factors, as they represent different aspects of a common construct. Therefore, we used an oblique rotation known as oblimin rotation. This is the most commonly used oblique rotation. A simple pre-registration was written for the analysis and can be found at https://aspredicted.org/iv24p.pdf.

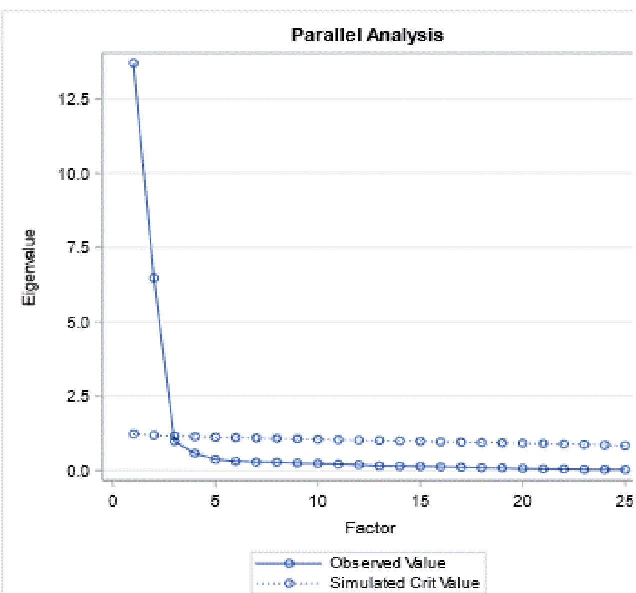
Results

The final sample consisted of 181 participants who rated 12 characters, resulting in a sample of 2172 sets of observations submitted to factor analysis. In keeping with our preregistration, an exploratory factor analysis was conducted on the covariance matrix, using principal axis factoring and an oblimin rotation. The de-identified raw data, the data converted to long format, and the SAS code can be found at https://osf.io/58c7e/?view_only=2c6e8bb90fd04c378809f8dcba290ec2.

The KMO measure of sampling adequacy and Bartlett's test indicated that the data were suitable for factor analysis. The KMO measure of sampling adequacy showed that a high proportion of the variance may be explained by common factors (.96). Bartlett's test of sphericity was significant, $X^2(300) = 88161$, $p < .0001$. These indicated that the data was highly suited for factor analysis.

Figure 3

The Scree Plot Showing the Real Eigenvalues and the Simulated Eigenvalues from Parallel Analysis



The K1 criteria and explained variance criteria suggested two factors—the third factor had an eigenvalue of $\lambda = .7$ and explained less than 5% of the variance (3.4%). The two-factor model explained 94.5% of the variance and including the third factor only increased this to 97.9%. The parallel analysis also suggested two factors, as did the point of inflexion in the scree plot (Figure 3). This strongly suggests that the two-factor model is sufficient—including any further factors is contrary to all the selection criteria, only marginally increases the explained variance, and therefore likely only serves to make interpretability of factors more difficult.

Therefore, we retained the two-factor solution after oblimin rotation. The resulting factor structure produced a simple structure, in which almost all items loaded on only one factor with cross-loadings near zero, with only one capacity ("can learn by imitation") cross-loading above .3 (Table 2). The inter-factor correlation was .32. This shows that while the factors are correlated—as are most factors extracted in psychological studies—they are not so highly correlated as to question the validity of a differentiated factor model.

Table 2

The Rotated Factor Pattern Showing Item Loadings on the Two Retained Factors, Items Organised by Malle's (2019) Component Labels.

Malle's (2019) Components	Mental Capacities	Factor 1	Factor 2
Affect	Can feel hungry.	.98	.
	Can feel pain	.99	.
	Can feel pleasure	.96	.
	Can feel panic	.98	.
	Can feel happy	.96	.
	Can have emotions	.95	.
	Can get angry	.92	.
	Can love specific people	.73	.
	Can have intense urges	.86	.
	Can smell and taste	.96	.
Mental & Moral Regulation	Can provide reasons for their actions	.	.88
	Can plan for the	.	.86

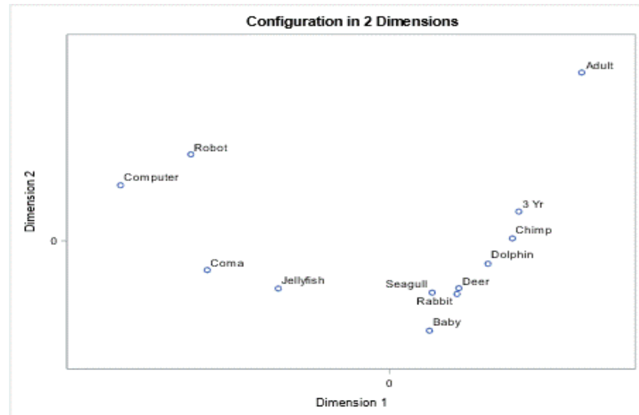
Malle's (2019) Components	Mental Capacities	Factor 1	Factor 2
	future		
	Can uphold moral values	.	.88
	Can understand a person's goals	.	.90
	Can explain their decisions	.	.95
	Can set goals	.	.91
	Can praise moral actions	.	.92
	Can disapprove of immoral actions	.	.90
	Can reason logically	.	.90
	Can understand others' minds	.	.80
Reality interaction	Can move on their own	.67	.
	Can see or hear the world around them	.82	.
	Can learn by imitation	.60	.30
	Can communicate non-verbally	.53	.29
	Can feel temperature/touch	.91	.

Note. With one exception, loadings below are 0.3 withheld for ease of interpretation.

As seen in Table 2, the first two dimensions from Malle (2019) were replicated here. However, the items that loaded on the Reality Interaction factor (third factor) loaded primarily on the first factor in this analysis. Three of these items were the most problematic in the analysis: "can move on their own, can learn by imitation", and "can communicate non-verbally" had the lowest loadings of all the items. "Can learn by imitation" cross-loaded onto the second factor and "can communicate non-verbally" cross-loaded at .29—below the automatic limit of .3 in SAS, though this .3 limit is somewhat arbitrary. The loading was so marginal we saw fit to include it.

Figure 4

Multidimensional Scaling of Character Ratings



Exploratory Analysis

Like Gray et al. (2007), we performed a multidimensional scaling (MDS) on the characters to visualise character ratings on the two dimensions (Figure 4). This is a method of not only visualising the way in which the schema of mind perception causes individuals to categorise other beings but is also an effective method for data quality verification in our study by comparing character ratings with previous studies. If the multidimensional scaling showed that a jellyfish was placed higher on dimension 1 (Affect) than an adult human, for example, it would indicate that despite coherent item loadings, the overall scores for the characters are problematic and may indicate poor responding or problematic data. However, the multidimensional scaling shows an intuitive pattern. The pattern of relationships between characters is similar to the pattern seen in Gray et al. (2007): dimension 1 corresponds with Gray et al.'s Experience factor (Malle's (2019) Affect), and dimension 2 with Gray et al.'s Agency factor (Malle's Mental and Moral Regulation).

The main dimension which captures the differences between vertebrates is Agency, or the Mental and Moral Regulation dimension. As the characters increase from "lower" to "higher" animals, the biggest change occurs in regard to the Agency dimension, with only moderate changes in Experience. The most relevant dimension that captures the difference between ratings of biological vs. artificial minds is Experience, or the Affect, dimension. There is a clear separation between biological and artificial entities on the affect dimension, while the artificial minds were rated higher on Agency than most of the animals.

Discussion

Contrary to our hypothesis, a two-factor model of mind perception was found: the Affect and Mental and Moral Regulation factors from Malle (2019) were the same, however, the items that composed the Reality Interaction dimension loaded primarily on the Affect dimension with some cross-loadings onto Mental and Moral Regulation. As noted by Malle, the Affect and Mental and Moral Regulation dimensions correspond to Gray et al.'s (2007) Experience and Agency dimensions; Malle has simply improved and altered the items used. Therefore, excluding the problematic Reality Interaction items, we have found a much cleaner two-factor structure that bears great resemblance to the original Agency-Experience model of mind perception, using the better items developed by Malle.

The five Reality Interaction items from Malle (2019) loaded on the first dimension in the analysis. Of these five, "can see or hear the world around them" and "can feel temperature/touch" loaded especially high on the first factor. These items align with the other items of that factor, as they pertain, using Gray et al.'s (2007) label, to Experience—both affective and basic sensory experience. Even in Malle's original analysis, Affect contains items pertaining to basic sensory experience ("can smell and taste things"). It seems appropriate then that the items "can see or hear the world around them" and "can feel temperature/touch" would load highly on the first factor, and the label Experience rather than Affect is appropriate as it pertains to affective states and basic sensory experience.

The items "can learn by imitation" and "can communicate non-verbally" loaded on the Affect, or Experience, dimension, but cross-loaded onto the Mental and Moral Regulation, or Agency, factor. This factor pertains to the capacity to deliberate, choose, plan, and think in both Malle (2019) and Gray et al. (2007). It seems appropriate that these items would load on the Agency, or Mental and Moral Regulation, factor, as learning and communicating are more complex, agentic, and cognitive abilities than they are experiential. It is not clear why these items loaded higher on the Affect/Experience factor than the Mental and Moral Regulation/Agency factor. It may be that the qualifiers "by imitation" and "non-verbally" signalled to the participants that these were to be thought of as 'lower order' behaviours—"learning by imitation" may have engendered thoughts of simple observation and copying behaviour and "communicating non-verbally" may have elicited thoughts of simple emoting behaviours. This may explain why they were correlated more highly with the Experience dimension. The learning and communicating aspect of the items may have then caused the cross-loading onto the more cognitive factor. Therefore, the cross-loading of these items is likely a result of poor item wording—the wording contains signifiers of both factors, causing cross-loading.

The item "can move on their own" did not cross-load but showed the lowest loading (aside from the two cross-loadings) of .67. This item does not itself pertain directly to mental capacities and the original factor it was thought to reflect has not been extracted from this analysis. Unlike "can see or hear the world around them" and "can feel temperature/touch", it does not seem relevant to a factor pertaining to experience, and self-directed movement is not necessarily a signifier of agentic and mental abilities. Therefore, this item should not be included in future mind perception questionnaires it likely has no relevance to mind perception.

Upon closer inspection of Malle's (2019) study, the Reality Interaction factor was problematic from the beginning: there was evidence of confounding of the first and third factors. Three of the five Reality Interaction items cross-loaded highly on the Affect dimension, however, Malle neglected to highlight this in their cross-loadings: they highlighted cross-loading items between Affect and Mental and Moral Regulation but neglected the cross-loadings between Reality Interaction and Affect items. Three of the five Reality Interaction items cross-loaded onto

Affect in their study. This mirrors the cross-loading seen in the present study and means that only two items in the original Malle study loaded unproblematically on the third factor: “learning by imitation” and “moving on their own”. This shows that the Reality Interaction factor is problematic. This third factor explains little variation in the data, many of the items load on the Affect dimension, and the items are conceptually and semantically problematic. On the other hand, the first two factors have a cohesive and defined conceptual structure.

Therefore, we provided strong support for a two-factor model of mind perception. An inspection of the items would suggest that Experience is the most appropriate label for the first factor because it pertains to both affective states (anger, fear), the experience of physiologically based states (hunger), and basic sensory experience (sight, smell, taste). The second factor is suited to both the Agency and the Mental and Moral Regulation labels, however, Gray et al.’s (2007) model is well-known and has been used in many studies in psychology. Therefore, we think it is appropriate to use Gray et al.’s (2007) Agency-Experience labels for the two-factor model of mind perception but use the improved and expanded questionnaire based on Malle’s (2019) items (excluding the Reality Interaction items except “can see or hear the world around them” and “can feel temperature/touch”, which loaded very highly on Experience).

While we have not replicated Malle’s (2019) Reality Interaction factor here—and we do not think it constitutes a dimension of the cognitive schema used for mind perception—Reality Interaction is still likely relevant to mind perception. A sense of some form of Reality Interaction in observed phenomena may be the absolute threshold for mind perceptions to occur. The absolute threshold is the lowest level of a stimulus needed to trigger a response or to be ”noticed” by sensory and/or cognitive processes (Corso, 1963). As described by Epley and Waytz (2010) people begin to use mental states to describe the movements of any objects that appear to be able to move or interact with the world. In this way, an object or being’s ability for reality interaction is likely the absolute threshold—the trigger—for mind perception inferences to occur.

Study Strengths and Limitations

The present study has helped to clear up and correct some of the issues in the mind perception literature and provided good evidence that a two-factor rather than three-factor model and measure of mind perception is more appropriate. Our study uses Malle’s (2019) improved items, a proper latent-factor analysis, and a larger sample of observations than those usually seen in the literature. We also hope that our study provides an accessible summary of the application of principal components analysis vs. factor analysis and a simple template for performing an exploratory factor analysis in psychology.

However, the present study may not be generalisable to non-WEIRD populations (Henrich et al., 2010). This study used a convenience sample of Australasian participants active on Prolific, and though the sample size was adequate for the analyses, the convenience sample itself constitutes a threat to the external validity of the study.

Additionally, one of the assumptions of factor analysis, that of conditional independence, was not significantly addressed in our study. Though we have rarely ever seen it addressed in the psychological literature in general, there are those who emphasise its importance and assert that it is an assumption which should be addressed (White et al., 2022). A discussion of conditional independence is beyond the scope of this research, though it presents a limitation of our study and offers an opportunity to critique the extensive use of factor analysis in the psychological literature in general.

Future Directions

In order to test the nested-sets hypothesis, future research should focus on performing confirmatory analyses of the two-factor model and constructing a valid measure of mind perception that can become the standard measure to be used across studies. A dedicated item analysis should be performed to investigate item wording, questionnaire structure, and reliability and validity analysis. A standard mind perception measure will improve the validity of the mind perception literature and make reviews and meta-analyses more feasible. This will allow the research on mind perception to comprise a more cohesive field of study.

The present study has addressed some of the issues surrounding the study of the dimensions of mind perception, using Malle's (2019) improved questionnaire and a methodology which addresses the limitations of both Malle and Gray et al. (2007). We have provided an independent replication of a two-factor structure similar to that of the fields' landmark study by Gray et al. (2007). The results provide support for the theory that humans categorise other beings along two primary dimensions of distinct mental abilities: the ability to feel fundamental affective states and the ability to regulate one's thoughts and behaviour.

Conflict of Interest

The author declares no conflicts of interest.

Contributorship Statement

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Acknowledgements

This paper was generously supported and supervised by Dr. Michael Phillip from Massey University, New Zealand.

References

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, *21*(1), 37-46. https://doi.org/10.1016/0010-0277(85)90022-8

Bartlett, M. S. (1950). Tests of significance in factor analysis. *British Journal of Statistical Psychology*, *3*(2), 77-85. https://doi.org/10.1111/j.2044-83171950.tb00285.x

Bastian, B., Loughnan, S., Haslam, N., & Radke, H. R. (2012). Don't mind meat? The denial of mind to animals used for human consumption. *Personal Social Psychology Bulletin, 38*(2), 247-256. https://doi.org/10.1177/014616721142429

Ben-Zeev, A. (1988). The schema paradigm in perception. *The Journal of Mind and Behaviour*, *9*(4), 487-513. https://www.jstor.org/stable/43853460

Bollen, K. A. (2002). Latent variables in psychology and the social sciences. *Annual Review of Psychology*, *53*(1), 605-634. https://doi.org/10.1146/annurev.psych.53.100901.1352393

Borgatta, E. F., Kercher, K., & Stull, D. E. (1986). A cautionary note on the use of principal components analysis. *Sociological Methods & Research*, *15*(1-2),160-168. https://doi.org/10.1177/00491241860150010

Bryant, F.B., and Yarnold, P.R. (1995). Principal-components analysis and exploratory and confirmatory factor analysis. In Grimm, L.G. & Yarnold, P.R., (Eds.), *Reading and understanding multivariate statistics* (pp. 99–136). American Psychological Association.

Buck, B., Hester, N., Penn, D. L., & Gray, K. (2017). Differential patterns in mind perception in subclinical paranoia: Relationships to self-reported empathy. *Cognitive Neuropsychiatry*, *22*(2), 137-144. https://doi.org/10.1080/1354805.2017.1287692

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research*, *1*(2), 245-276. Doi: 10.1207/s15327906mbr0102_10

Corso, J. F. (1963). A theoretico-historical review of the threshold concept. *Psychological Bulletin*, *60*(4), 356-370. https://doi.org/10.1037/h0040633

Costello, A. B., & Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research, and Evaluation*, *10*(1), 7. https://doi.org/10.7275/jyj1-4868

d'Andrade, R. (1987). A folk model of the mind. In Holland, D., & Quinn, N., (Eds.), *Cultural Models in Language and Thought*, 112-148. Cambridge University Press.

De Winter, J. C., & Dodou, D. (2012). Factor recovery by principal axis factoring and maximum likelihood factor analysis as a function of factor pattern and sample size. *Journal of Applied Statistics*, *39*(4), 695-710. https://doi.org/10.1080/02664763.2011.610445

Epley, N., & Waytz, A. G. (2010). Mind perception. In *Handbook of Social Psychology* (pp. 498-541). John Wiley & Sons, Inc. https://doi.org/10.1002/97800470561119.socpsy001014

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *358*(1431), 459-473. https://doi.org/10.1098/rstb.2002.1218

Guadagnoli, E., & Velicer, W. F. (1988). Relation of sample size to the stability of component patterns. *Psychological Bulletin*, *103*(2), 265-275. https://doi.org/10.1037/0033-2909.103.2.265

Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science, 315*(5812), 619.

Gray, K., & Wegner, D. M. (2012). Feeling robots and human zombies: Mind perception and the uncanny valley. *Cognition*, *125*(1), 125-130. https://doi.org10.1016/j.cognition.2012.06.007

Gray, K., Jenkins, A. C., Heberlein, A. S., & Wegner, D. M. (2011). Distortions of mind perception in psychopathology. *Proceedings of the National Academy of Sciences*, *108*(2), 477-479. https://doi.org/10.1073/pnas.1015493108

Gray, K., Young, L., & Waytz, A. (2012). Mind perception is the essence of morality. *Psychological Inquiry, 23*(2), 101-124. https://doi.org/10.1080/1047840X.2012.651387

Haslam, N., & Loughnan, S. (2014). Dehumanization and infrahumanization. *Annual Review of Psychology*, *65*, 399-423. Doi: 10.1146/annurev-psyc-010213-115045

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2-3), 61-83. https://doi.org/10.1017/S0140525X0999152X

Johnson, S. C. (2000). The recognition of mentalistic agents in infancy. *Trends in Cognitive Sciences*, *4*(1), 22–28.

https://doi.org/10.1016/S1364-6613(99)01414-X

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*(1), 141-151. https://doi.org/10.1177/001316446002000116

Kaiser, H. F. (1970). A second generation little jiffy. Psychometrika, 35(4), 401-415. Doi: 10.1007/BF02291817

Lee, M., Lucas, G., Mell, J., Johnson, E., & Gratch, J. (2019). What's on your virtual mind? Mind perception in human-agent negotiations. In *Proceedings of the 19th acm international conference on intelligent virtual agents,* 38-45. https://doi.org/10.1145/3308532.3329465

Loughnan, S., Bastian, B., & Haslam, N. (2014). The psychology of eating animals. *Current Directions in Psychological Science, 23*(2), 104-108. https://doi.org/10.1177/0963721414525781

Malle, B. F. (2019). How many dimensions of mind perception really are there? In A. K. Goel, C. M. Seifert, & C. Freska (Eds.), *Proceedings of the 41st Annual Meeting of the Cognitive Science Society*. 2268-2274.

Matsunaga, M. (2010). How to factor-analyze your data right: Do's, don'ts, and how-to's. *International Journal of Psychological Research*, *3*(1), 97-110. https://doi.org/10.21500/20112084.854

O'connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers*, *32*(3), 396-402.

Osborne, J. W. (2014). *Best practices in exploratory factor analysis*. CreateSpace Independent Publishing.

Osborne, J. W., & Banjanovic, E. S. (2016). *Exploratory factor analysis with SAS*. SAS Institute.

Saris, W. E., & Revilla, M. (2016). Correction for measurement errors in survey research: Necessary and possible. *Social Indicators Research*, *127*(3), 1005-1020. https://doi.org/10.1007/s11205-015-1002-x

Tharp, M., Holtzman, N. S., & Eadeh, F. R. (2016). Mind perception and individual differences: A replication and extension. *Basic and Applied Social Psychology, 39*(1), 68-73. https://doi.org/10.1080/01973533.2016.1256287

Wang, X., & Krumhuber, E. G. (2018). Mind perception of robots varies with their economic versus social function. *Frontiers in Psychology*, *9*, 1230. https://doi.org/10.3389/fpsyg.2018.01230

Waytz, A., Gray, K., Epley, N., & Wegner, D. M. (2010). Causes and consequences of mind perception. *Trends in Cognitive Sciences*, *14*(8), 383-388. https://doi.org/10.1016/j.tics.2010.05.006

Weisman, K., Dweck, C. S., & Markman, E. M. (2017). Rethinking people's conceptions of mental life. *Proceedings of the National Academy of Sciences, 114*(43), 11374-11379. https://doi.org/10.1073/pnas.1704347114

White, M., Edelsbrunner, P. A., & Thurn, C. M. (2022). The conceptualization implies the statistical model: Implications for measuring teaching quality. https://doi.org/10.31219/osf.io/zksbt

Widaman, K. F. (1993). Common factor analysis versus principal component analysis: Differential bias in representing model parameters? *Multivariate Behavioral Research*, *28*(3), 263-311. https://doi.org/10.1207/s15327906mbr2803_1

Willard, A. K., & McNamara, R. A. (2019). The minds of god(s) and humans: Differences in mind perception in Fiji and North America. *Cognitive Science*, *43*(1). https://doi.org/10.1111/cogs.12703

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, *8*(3).

Wiens, S. (2017). Aladins Bayes Factor in R (Version 3) [Computer Software]. Retrieved from https://doi.org/10.17045/sthlmuni.4981