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Articles

Structural Equations for Testing Nested Models in Interdisciplinary Research

Ecuaciones estructurales para la prueba de modelos anidados en investigación interdisciplinaria

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Abstract

Barriers to compare opposed or alternative scientific theories exist, based on diverse premises. One is the concept of incommensurability, the idea suggesting that different paradigms or theories cannot be contrasted since they do not share common tenets. This paper proposes the use of nested models for testing the efficacy of isolated disciplinary explanations of psychological and social problems versus the power of interdisciplinary explanations. According to this approach, such nested models would include alternative disciplinary theories competing against each other and against an inclusive model that combines these unidisciplinary explanations. This situation is illustrated with an empirical study using a questionnaire on predictors of precautionary behaviors against COVID-19. Data was analyzed using structural equations, considering a psychological and a health-science perspective, and integrated into an interdisciplinary model. Results from this study showed that the best model was the interdisciplinary model, thus providing some evidence for the use of nested models as a method to integrate different disciplines. The advantages of this approach are discussed in the face of the growing, complex, and serious problems that humanity is nowadays experiencing.

Keywords: interdiscipline, psychology, health sciences, nested models, structural equations

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Resumen

Basadas en diversas premisas, existen barreras para comparar teorías científicas opuestas o alternativas. El concepto de inconmensurabilidad es una de estas dificultades, la idea que sugiere que diferentes paradigmas o teorías no pueden contrastarse porque no comparten principios comunes. Este artículo propone el uso de modelos anidados para probar la eficacia de explicaciones disciplinarias aisladas de problemas psicológicos y sociales en comparación con la de explicaciones interdisciplinarias. Según este enfoque, tales modelos anidados incluirían teorías disciplinarias alternativas que compiten entre sí y contra un modelo inclusivo que combine estas explicaciones unidisciplinarias. Esta situación se ilustra con un estudio empírico sobre predictores de conductas de precaución frente al COVID-19. Los resultados fueron analizados mediante ecuaciones estructurales, considerando una perspectiva psicológica y de ciencias de la salud, e integrados en un modelo interdisciplinario. Los hallazgos mostraron que era mejor el modelo interdisciplinario, proporcionando evidencia para el uso de modelos anidados como método para integrar diferentes disciplinas. Se discuten las ventajas de utilizar este enfoque frente a los crecientes, complejos y graves problemas que vive hoy la humanidad.

Palabras clave: interdisciplina, psicología, ciencias de la salud, modelos anidados, ecuaciones estructurales

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Introduction

In these times, research has become increasingly interdisciplinary, and societies around the globe demand science's involvement in solving global problems. Such demand has altered academic practices and disciplinary relations. As a result, terms such as 'discipline' and 'interdisciplinary' are at the center of debates (Klein, 2000). For example, regarding the study of human health and wellbeing, Bhaskar et al. (2018) state:

Nowhere is the need for genuine interdisciplinarity more evident than in research related to health and wellbeing. For a human being is patently a totality and cannot be studied as a congeries of distinct and separable parts. Thus, a person cannot be perceived as being made up of a number of parts that relate to distinct disciplines. She is a totality; and therefore, requires treatment in a thoroughly interdisciplinary way. (p. 3)

The same can be said about the totality of society, the planet, and every issue concerning them: violence and war, climate change, health issues and pandemics, famine, inequality, and a large etcetera. In those issues, the physical, biological, economic, and psychological components are just facets of a whole, integrated phenomenon that must be examined, as much as possible, in its totality.

According to the National Academy of Sciences (2005):

Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice. (p. 39)

One defining feature of interdisciplinary research is the integration of knowledge from different disciplines, assuming that we know what the term discipline stands for and what components of disciplines have to be considered in such integration of knowledge (Glänzel & Debackere, 2022).



Therefore, an interdisciplinary study emerges from combining and integrating two or more disciplines, including their theories and methodologies. This implies crossing the boundaries between sciences and mixing their techniques in trying to achieve a common goal. In an interdisciplinary project, methods and theoretical assumptions from different disciplines can be connected and modified according to the needs of the research (Zaman & Goschin, 2010). Sometimes this involves the creation of new tools for the study of complex problems that overcome the possibilities of a single discipline. In psychology, for example, complex topics such as conscience, wellbeing, or self-determination involve several approaches that combine behavioral science, biology, physics, economics, and anthropology, among others. In fact, every aspect of psychological interest could and perhaps should be studied following this multi-faceted, integrative approach (Gevonden, 2007).

Despite the evident need for conducting interdisciplinary research, especially in addressing complex psychological and social issues, a rejection of this approach is still noticed. A number of reasons are presented, varying from the difficulty of conducting interdisciplinary research to the impossibility of mixing disciplines since they possess “clear” boundaries. Interdisciplinary studies aimed at addressing and solving social problems face structural, cultural, and cognitive barriers and problems related to disciplines as social institutions. Buanes and Jentoft (2009) claim structural barriers that are the easiest to address, whereas cultural barriers are more difficult to overcome because they require more than a regulatory fix.

The aim of this paper is to illustrate how structural equations and nested model comparison can be used to conduct interdisciplinary research. First, a discussion on barriers preventing the integration and contrast of disciplines to explain social phenomena is conducted. Secondly, the advantages of nested model comparison are discussed, illustrating its use with empirical data from a study of precautionary behaviors against COVID-19.



Incommensurability and interdisciplinarity

Even if we accept interdisciplinarity as a research approach, we also need to be aware of the barriers involved in its conduction. One of these barriers is incommensurability.

Based on the influential ideas of Thomas Kuhn (1962), a movement in science maintains that the contrast between opposed theories explaining a due phenomenon cannot, and should not, be performed. Kuhn established that principle, reasoning that these opposed theories do not share common tenets (i.e., the same explanatory variables and their relations). Therefore, they are *incommensurable*. For example, in psychology, according to this principle, a mentalist model cannot be contrasted against a behaviorist approach because the explanations of the former are internal (organismic) variables, while the latter are external (environmental). Although the variable to explain is usually the same: in people's behavior, the explanatory variables are different from each other and, very often, they are opposed to the alternative explanatory framework. Despite the fact that Kuhn's idea was challenged by a number of researchers and philosophers (see Lakatos, 1980, for example), the obstacle of incommensurability still permeates the rejection of the idea that alternative theoretical frameworks can be integrated or contrasted with each other within a discipline. Moreover, this barrier also affects interdisciplinary research since, for many, the irreducibility of discourses characterizing every discipline, and the fact that all sciences have unique "complications", makes disciplinary integration difficult (McMurtry, 2009).

In fact, Kuhn (1962) believed that the proliferation of specialties in science is driven by incommensurability. He utilized 'incommensurability' to refer to disciplines' lack of a common measure for achieving an objective comparison of two competing paradigms. This incommensurability included the lack of a shared theoretical vocabulary, the lack of shared methodologies, and the lack of a common worldview in trying to explain problems (Politi, 2017). Kuhn himself believed that incommensurability does not mean incommunicability, although the possibility of communication does not deny the existence of



incommensurability. *Semantic incommensurability* (the lack of a shared theoretical vocabulary) is thought to prevent the comparison of opposed theories since there are no common aspects to contrast, and this also applies to *worldview incommensurability*, the lack of common grounds in alternative sources of insight. *Methodological incommensurability*, in turn, is driven by innovations in methods (i.e., new tools for research) inside a scientific discipline so that, according to Chang (2013), a big deal of revolutionary scientific change manifests by methodological rather than by semantic incommensurability.

However, even if this is the case, the creation of new methods addressing (new and already existing) phenomena does not prevent the contrast of data from different approaches. In fact, on grounds of scientific validity, it could be argued that different methods should produce similar results if one is indeed measuring what is intended (Eid & Diener, 2006). Therefore, the contrast between different methods, theories, and disciplines is not only feasible but also necessary if a researcher aims to achieve solid validity in their measures.

Nested models for interdisciplinarity

One of the most important questions to respond to is how to proceed in conducting an interdisciplinary study. Different approaches have been proposed and implemented. One of them looks for the degree of interdisciplinarity present in the research, so that methods should be developed and applied to quantify and measure such aspect. In this regard, Glänzel et al. (2016) point at the ambiguity of the disciplinary assignment of research (i.e., lack of clarity concerning what research aspects belong to every discipline) in the context of data integration, so that this ambiguity affects the confidence in the degree of interdisciplinarity. In order to assess this aspect, a *cognitive approach* has been developed, trying to determine the use of information from different and not necessarily related topics in a new “cognitive” environment and context (Glänzel & Debackere, 2022). This approach sometimes assesses the use of information in citing papers, where multi-disciplinary bibliographic databases offer the opportunity to



benchmark across research fields. From this perspective, variety (number of topics), balance (distribution of topics), and disparity are considered as reflecting cognitive characteristics of interdisciplinarity (cf. Wang et al. 2015; Zhang et al. 2016). By using this approach, researchers can guarantee the presence of clear, distinguishable contributions from every discipline to the (semantic, methodological) interdisciplinary integration of their studies, avoiding ambiguity as much as possible.

Other approaches look for a way of integrating different disciplines within the context of research-design and data-analysis strategies. For example, in the health sciences, an interdisciplinary strategy takes the form of a holistic, multileveled, “cells-to-society” approach; in this strategy, health is conceived as depending on several living systems, from the cells and organs to the social, cultural, and ecological systems in which the individual participates. These multi-level systems are nested hierarchically, from the chemical and biological to the ecological, so that the person is conceived as a living system within larger systems.

When studying the events occurring in a marine system, Nihoul (2009) establishes that, the model to be developed for interdisciplinary research and sustainable development scenarios should inevitably be an assemblage of nested models. According to Nihoul (2009), the model “needed to simulate different scenarios of sustainable development will not be able to represent—in a single modeling edifice— all scales of motions and all hierarchical levels from microturbulence to synoptic eddies and climatic anomalies, from individual organisms to populations and their seasonal or year-to-year variations.” (p. 2). Therefore, multiple and nested models are necessary for representing those complex events. The nested model approach can also be applied to other subjects such as psychological experiences, violence, learning, and much more (McMurtry, 2009).

In statistics, a nested model is a regression model that contains a subset of the predictor variables in another regression model. Researchers use nested models in practice when they want to know if a model with a full set of predictor variables can fit a dataset better than a model with a subset of those predictor variables.



Comparison of nested models is commonly practiced when applying structural equation modeling (SEM). According to Bentler and Bonett (1980), two models are parameter-nested if the parameters of the more restricted model include some but not all the parameters of the less restricted model. The more restricted model is the one with less variables and correlations. The researcher sometimes aims at demonstrating that this restricted (more parsimonious) model is as good as the less restricted one in terms of explanatory power; yet the alternative finding usually occurs, showing that adding more variables and parameters significantly increases such power.

This quantitative analytical strategy may also be used for contrasting two or more particular models nested in an integrative model containing the particular models. Following this strategy, two or more alternative models are specified to compete against each other and against the inclusive model. The explanatory power of each model (including the integrative one) is calculated by obtaining the R^2 produced on the dependent variable. The preferred model is the one resulting in a higher R^2 . A hypothesis testing is required to ensure the statistical significance of the explanatory-power obtained difference. Usually, a chi-squared difference (χ^2_{diff}) is used to assess if a significant difference exists between the two models (Crede & Harms, 2019). The χ^2_{diff} is calculated by subtracting the model with a χ^2 of lower value from the model with a χ^2 of higher value. Additionally, the degrees of freedom (df) for the models are subtracted (i.e., subtracting the lower df from the higher). This χ^2 diff-value is distributed with df_{diff} degrees of freedom and can be checked manually for statistical significance using a χ^2 table (Werner & Schermelleh-Engel, 2010). The models' goodness of fit is also contrasted in determining the superiority of those alternative explanations. The one with the highest R^2 , best goodness of fit, and significantly different from the other(s) model(s) is preferred over the alternative representations. This "superior" model should not be significantly different from the inclusive model because it explains as much (and is more parsimonious). However, if all



the competing representations are significantly different from the integrative model, the researcher should conclude that the latter is the best at explaining the dependent variable.

To illustrate the use of structural nested models for interdisciplinary research, data from a study of precautionary actions against COVID-19 was selected. Having various disciplines is more useful for the topic of COVID-19 because the explanatory power of a model of predictors of precautionary behavior increases when diverse disciplines are integrated. In this vein, Bontempi et al. (2020) argue and demonstrate that research on COVID-19 diffusion patterns must consider multiple diffusion patterns that are approached by diverse disciplines. Decades ago, Klein (1990) criticized the fact that, when addressing global pandemics, research is usually limited to a specific field (health, environmental, or economic aspects), and researchers are biased by excessive disciplinary specialization. Furthermore, Bontempi et al. (2020) establish that “developing a comprehensive vision of COVID-19 contagion requires more variables than usual (unidisciplinary) research” (p. 2).

In our study, two disciplinary models are considered in this simple example: one from *health science* emphasizing aspects of physical health, such as physical exercise, personal hygiene, healthy nutrition, visits to a physician, and general physical health as aspects that stimulate precautionary measures against the disease. The second *psychological* model encompasses empathy and impulsivity as psychological traits related to the prevention of COVID-19. These are considered restricted models, nested in an integrative model encompassing the disciplinary models, which compete with each other and against the integrative model.



Method

The data comes from a study developed in the beginnings of the COVID-19 pandemics (May 2020) in Mexico. Frías et al. (2021) reported a detailed summary of this study.

Participants

The sample consisted of 709 individuals living in 24 of the 32 Mexican states. All of them at or above the legal age of consent (18). Mean age was 35.5 ($sd = 14.8$), ranging from 18 to 81. Most of the participants self-identified as female (517), with 178 identified as male, seven as nonbinary, and seven did not answer.

Instruments

The instruments assessed psychological factors such as empathy and impulsivity. Variables related to general health practices (such as diet and exercise) and pandemic-specific precautionary behaviors (handwashing, social distancing, etc.) were assessed as well as self-report of general health condition. Empathy was assessed using four Likert-type (0-4) items from the Loewen et al. (2009) Empathy Quotient, which, in turn, is a short form of the one from Wakabayashi et al. (2006). Examples of these items include, “I find it hard to know what to do in a social situation” and “I often find it hard to judge if something is rude or polite.” The internal consistency of this scale was $\alpha = 0.64$. Impulsivity was assessed through eight items from the Corr and Cooper (2016) Reinforcement Sensitivity Theory Personality questionnaire. This instrument uses a response scale ranging from 1 (“it does not apply to me”) to 5 (“it absolutely applies to me”); with “I always buy things impulsively” and “I recognize that I do thing without thinking” as examples of this scale, which was translated to Spanish and validated by Espinoza-Romero et al. (2019) in Mexico. Its internal consistency was $\alpha = 0.74$.

Five items measuring general health practices were extracted from the Self-Care instrument by Corral-Verdugo et al. (2021), plus two items addressing general health. The instrument used a 5-point Likert-type scale ranging from “never” (1) to “always” (5). The scale showed acceptable internal consistency in our



sample ($\alpha = 0.63$). The precautionary behavior scale developed by Frías-Armenta et al. (2021) was used to assess actions that protect oneself and others against infection and transmission of COVID-19, including staying at home, social distancing, avoiding face-touching, re-entering home with precaution, and washing hands. The final two questions of this scale were qualitative to best assess the precautionary measures reported by the participants. This was aimed at identifying additional safe behaviors thought to protect against the virus in the initial stages of the pandemic.

Data analysis

Univariate statistics (means and standard deviations) were obtained for the items used in the study, as well as reliability coefficients (Cronbach's alpha and McDonald's omega) for the scales. An average inter-item correlation (AIC) analysis was performed for estimating the reliability of the Precautionary Behaviors measure since it included items with diverse codification (ranges of response: 1–5, 1–4, –3 to 2, 0–7, and 0–6).

The nested models comparison was performed using structural equations through EQS, version 6.0. Maximum likelihood robust was used as the estimation method for an input of raw data.

The maximum likelihood robust method was used because, although we have a large sample, a previously specified model, and independent observations, we did not meet the normal distribution of the data (Mardia = 67.95). This methodology and the residual based tests are thought to be the most accurate methods for analyzing non-normal data for structural equation models (Bentler, 2007).

Three models were specified and tested. The first included a factor of healthy actions and a manifest variable indicating general health conditions as predictors of precautionary behaviors; consequently, this was the *health science model*. The second model specified two psychological traits—impulsivity and empathy—as factors affecting precautionary behaviors, also specifying that impulsivity affects empathy; this was the *psychological model*. The third model included the former two and was considered the



integrative interdisciplinary model; in addition to the abovementioned causal paths, this model proposed a link between the two unidisciplinary representations: impulsivity affecting healthy actions. The main interest of our proposal is testing the explanatory power of unidisciplinary models vs. an interdisciplinary integrative model. The direct effect (indicated by the R^2 of every model) is the one taken into account.

R^2 and goodness of fit indicators were obtained for the three models, including χ^2 , the BNNFI and CFI practical goodness of fit indexes, and RMSEA. The χ^2_{diff} was calculated, as described in the introductory section, to estimate differences between models. Differences in R^2 and goodness of fit were also estimated.

Procedure

The data were collected using a snowball recruitment procedure. Study invitations were sent via email, text, and social media to researchers and colleagues in diverse states throughout Mexico, asking for their assistance in recruiting participants. The data were collected through Qualtrics. This procedure was selected to keeping with physical distancing guidelines. Prior to participation, all respondents were informed of the study's aims, benefits, and risks before signing a digital consent form.

Results

Table 1 shows the univariate statistics as well as the reliability (internal consistency) of the three scales used to predict the dependent variable. The Cronbach's alphas ranged from 0.60 to 0.74, while McDonald's omegas ranged from 0.62 to 0.76. The average inter-item correlation (AIC) analysis, performed for estimating the reliability of the Precautionary Behaviors measure, produced an $AIC = 0.16$, which is considered acceptable (Briggs & Cheek, 1986; Clark & Watson, 1995).



Table 1*Univariate Statistics and Reliability of Scales*

SCALE/Items	Mean	SD	Alpha	Omega
PRECAUTIONARY BEHAVIORS			----- *	-----
Stays at home	4.02	0.79		
Keeps distance	4.63	0.57		
Don't touches face	4.03	0.97		
Precaution entering home	4.78	0.54		
Washing hands	4.46	0.73		
HEALTHY ACTIONS			0.62	0.66
Personal hygiene	3.74	0.76		
Physical Exercise	3.64	1.00		
Healthy food	4.74	0.51		
Go to doctor	4.24	0.78		
IMPULSIVITY			0.75	0.76
Talks a lot	2.22	1.00		
Risky behavior	1.89	0.91		
Thoughtless	2.16	0.94		
Buys impulsive	2.00	0.99		
Acts involuntarily	2.22	0.96		
EMPATHY			0.60	0.62
Perceives rudeness	3.93	1.00		
Perceives discomfort	3.90	0.91		
(S)he is sensible	4.20	0.95		

*AIC was instead obtained (see text)

The average variance extracted (AVE) was computed for the 4 assessed factors. The convergent validity is taken to be satisfactory if the measurement constructs have an AVE of at least 0.50 (Hair Jr. et al.



1995). Results show that AVE ranged from 0.46 to 0.63, values that are close or greater than the recommended value. Consequently, in general, conditions for convergent validity were met (see Table 2).

A phi matrix showed that all factors are significantly ($p > 0.05$) interrelated (see Table 3). The matrix includes a diagonal with the squared average variance extracted (SAVE) for every construct. All the SAVE values were higher than the values of the correlation of every construct with the other, which indicates an appropriate discriminant validity for our measures (see Henseler et al. 2009).

Table 2

Factor Loadings, AVE and SAVE of the Used Scales

SCALE/Items	Factor/lambda	λ^2	AVE	SAVE
PRECAUTIONARY BEHAVIORS				
Stays at home	0.30	0.09		
Keeps distance	0.26	0.07		
Don't touches face	0.33	0.11		
Precaution entering home	0.64	0.41		
Washing hands	0.60	0.36		
		1.04/5 = .21	.46	
HEALTHY ACTIONS				
Personal hygiene	0.40	0.16		
Physical Exercise	0.53	0.28		
Healthy food	0.45	0.20		
Go to doctor	0.47	0.22		
		0.86/4 = .22	.47	
IMPULSIVITY				
Talks a lot	0.53	0.28		
Risky behavior	0.72	0.51		
Thoughtless	0.79	0.62		
Buys impulsively	0.50	0.25		
Acts involuntarily	0.58	0.34		
		2.00/5 = 0.40	0.63	
EMPATHY				
Perceives rudeness	0.58	0.34		
Risky behavior	0.72	0.52		
Thoughtless	0.44	0.19		
		1.05/3 = 0.35	0.59	



Table 3

Phi Matrix of Covariances and Squared Average Variance Extracted (SAVE, Bold Numbers in Diagonal)

	PRC	HLT	IMP	EMP
PRECAUTIONARY (PRC)	0.46			
HEALTHY ACTIONS (HLT)	0.45	0.47		
IMPULSIVITY (IMP)	-0.020	-0.025	0.63	
EMPATHY (EMP)	0.24	0.18	-0.46	0.59

The results of the tested models are shown in Figures 1 through 3. In model 1 (*health sciences*), both predictors—the factor healthy actions ($\beta = 0.53$), and the manifest variable general health conditions ($\beta = 0.23$)—positively and significantly ($p < 0.05$) influenced engagement in precautionary behaviors. The R^2 for this model was 0.23, meaning that these two predictors explain twenty-three percent of the variance in the dependent variable.

In model 2, only empathy ($\beta = 0.53$) produced a significant ($p < 0.05$) impact on precautionary behaviors; yet the influence of impulsivity was indirect, negatively affecting these precautionary activities through empathy ($\beta = -0.47$). This model performed poorly since it only explained eight percent of the dependent variable variance.

Finally, results from model 3 showed that healthy actions ($\beta = 0.47$) and empathy ($\beta = 0.24$), but not general health condition ($\beta = 0.09$) and impulsivity ($\beta = 0.10$), positively and significantly ($p < 0.05$) influenced precautionary behaviors against COVID-19. Impulsivity played the role of connection between the two disciplinary models, significantly ($p < 0.05$) and negatively affecting both healthy actions ($\beta = -0.35$) and empathy ($\beta = -0.47$). The R^2 for this model was 0.29.



The three models exhibited similar goodness of fit: the health sciences model resulted in $\chi^2=76.6$ (32 df , $p < 0.001$); $BBNNFI = 0.86$, $CFI = 0.90$, $RMSEA = 0.05$. The psychological model produced a $\chi^2= 139.2$ (62 df , $p < 0.001$); $BBNNFI = 0.90$, $CFI = 0.92$, $RMSEA = 0.05$. The goodness of fit indicators for the interdisciplinary model were: $\chi^2 = 262.2$ (129 df , $p < 0.001$); $BBNNFI = 0.86$, $CFI = 0.90$, $RMSEA = 0.04$.

Figure 1

The Disciplinary Health Model Predicting Precautionary Behaviors Against COVID-19

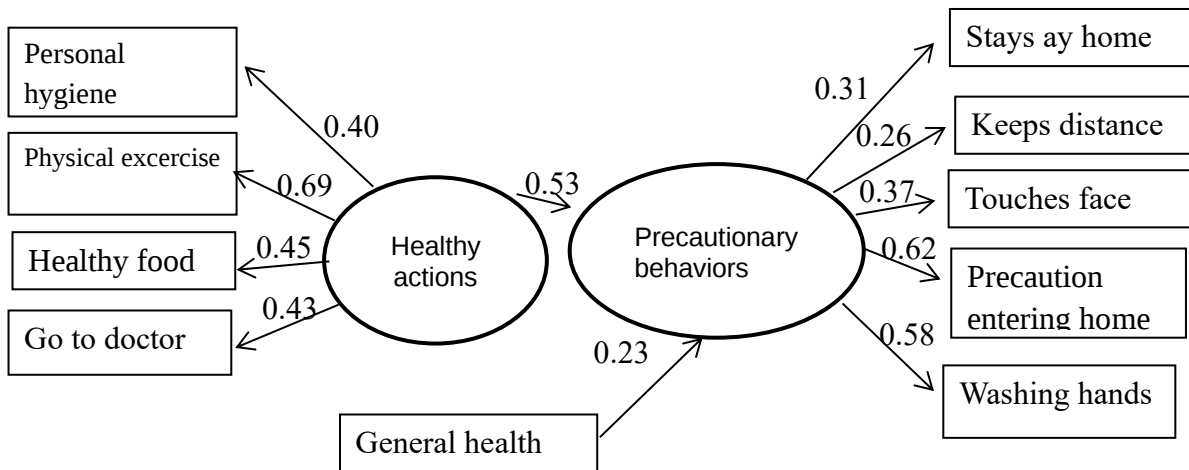


Figure 2

The Disciplinary (Trait) Psychological Model Predicting Precautionary Behaviors Against COVID-19

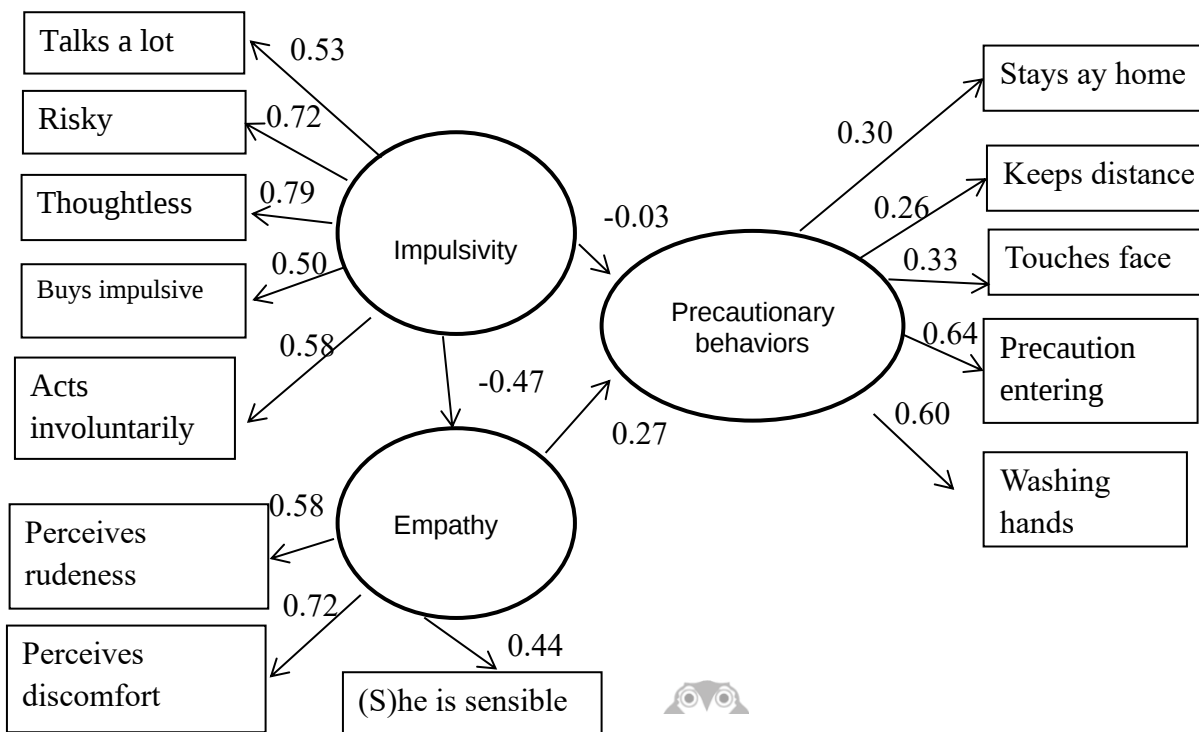
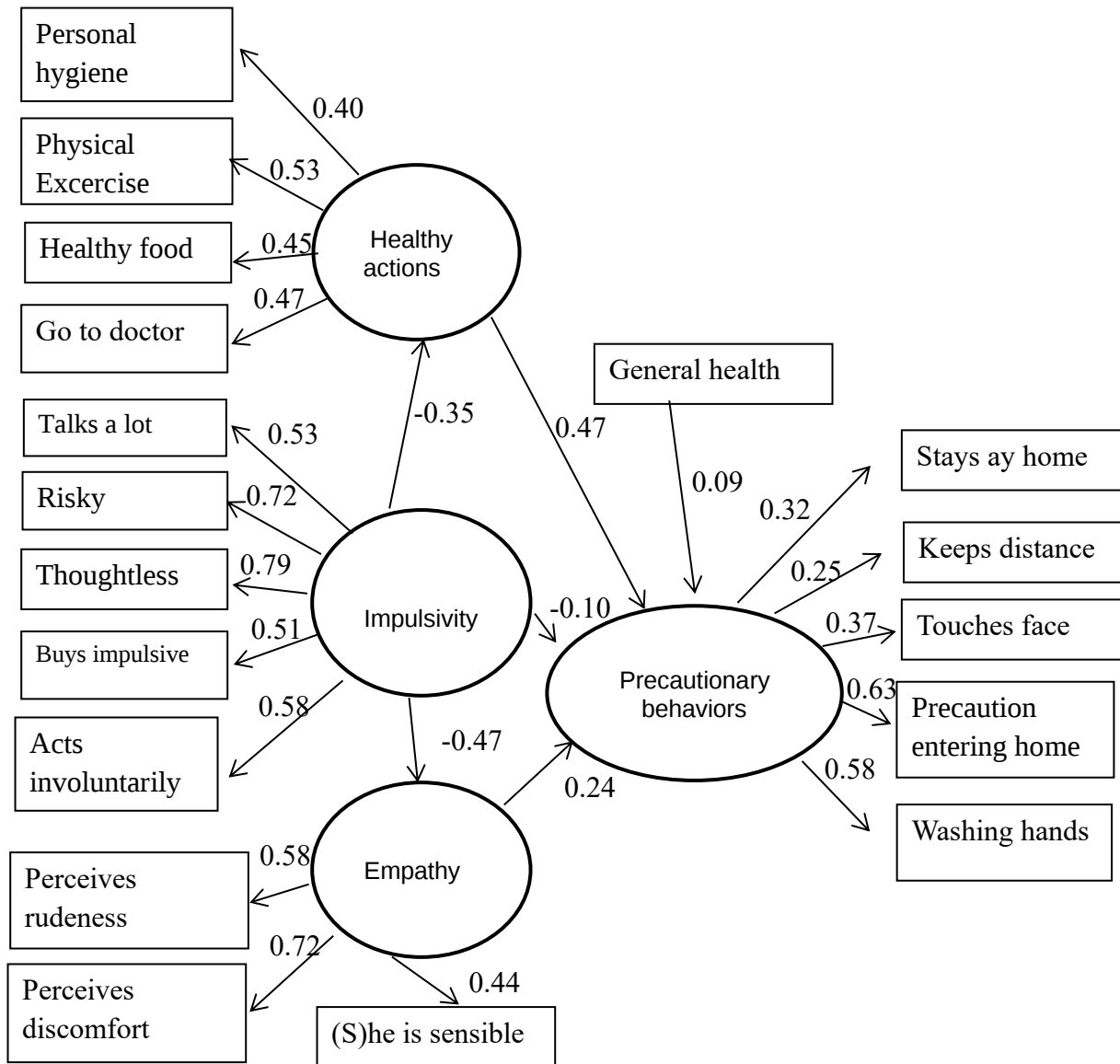


Figure 3

The Interdisciplinary Health-Psychological Model Predicting Precautionary Behaviors Against COVID-19



Finally, the Table 4 shows the statistics used to perform comparisons among the three models. As demonstrated, all comparisons resulted in statistically significant differences between models. The psychological model performed poorly in terms of explanatory power as compared to the health sciences model ($\text{Diff. } X^2 = 62.6; 30 \text{ Diff. df}; p < 0.01$); the R^2 difference in this contrast between disciplinary models

was 0.15. The difference is even higher when comparing the psychological model against the interdisciplinary model (*Diff. $X^2 = 123$; 67 *Diff. df*; $p < 0.001$*), which resulted in a R^2 difference = 0.21. Finally, a significant difference was found between the health sciences and interdisciplinary models (*Diff. $X^2 = 185.6$; 97 *Diff. df*; $p < 0.001$*). The difference favored the integrative model (*Diff $R^2 = 0.06$*). Differences in practical goodness of fit indicators were marginal (ranging from 0.00 to 0.04) as reported in Table 4.

Table 4*Nested Model Comparisons*

MODELS	X^2	<i>Df</i>	<i>p</i>	<i>NNFI</i>	<i>CFI</i>	<i>RMSEA</i>	R^2
1) Psychological traits	139.2	62	< 0.001	0.90	0.92	0.05	0.08
2) Health sciences	76.6	32	< 0.001	0.86	0.90	0.05	0.23
3) Interdisciplinary	262.2	129	< 0.001	0.86	0.90	0.04	0.29
COMPARISONS	<i>Diff. X^2</i>	<i>Diff. df</i>	<i>p</i>	<i>Diff NNFI</i>	<i>Diff CFI</i>	<i>Diff R^2</i>	
1 vs 2	62.6	30	< 0.01	0.04	0.02	0.15	
1 vs 3	123	67	< 0.001	0.04	0.02	0.21	
2 vs 3	185.6	97	< 0.001	0.00	0.00	0.06	



Discussion

Even issues labeled as uniquely unidisciplinary (behavior, economy, culture) offer a variety of aspects that cannot be addressed by one discipline (Griffin, 2015). As Godfrey and Torres (2016) point out, “siloeed” disciplinary explanations have proven incapable of drawing the lines and intersections of factors defining a social crisis. Psychology and its subjects are not exempt from this situation.

Although the need for interdisciplinarity is widely acknowledged, some barriers persist that prevent the conduction of interdisciplinary studies. Incommensurability, the absence of common concepts, methods and worldviews between different disciplines is one of those barriers. In this paper, it was argued that—despite that alleged barrier—diverse disciplines can communicate, supplement, and share concepts as well as methods, which leads to the contrast and integration of explanations and measures when trying to address an issue of interest. The conclusion is that absolute incommensurability is practically inexistent, and the interaction of different branches of science produced in interdisciplinarity is not only necessary but feasible.

This paper focused on the nested model approach that uses structural equations. Using data from a study on predictors of precautionary behaviors against COVID-19, this paper is intended to illustrate how structural equations can be used to conduct interdisciplinary research. The illustrative example was maintained as simple as possible, including, in the psychological model, two constructs (empathy and impulsivity) and eight observed indicators, predicting precautionary measures: a factor with five indicators. The health sciences model considered, in addition to the precautionary measures factor, one latent variable (healthy actions) and its four indicators, plus one observed variable labeled “general health”. Since interdisciplinarity is about theory integration, not just methods to integrate data, variables selected were representative of two different (psychological and health science) approaches.

The most complex model was, of course, the interdisciplinary one, which, in addition to specifying the paths from the four independent variables of the two disciplinary models on the dependent variable,



specified effects from impulsivity to both empathy and healthy actions. Results of the interdisciplinary model revealed that empathy and healthy actions significantly and positively influenced precautionary actions, replicating findings from the unidisciplinary models.

The between-model contrasts, using *diff. X^2* , established significant differences between the three models. Although no conspicuous differences in goodness of fit were noticed, the explanatory power was saliently higher in the interdisciplinary model, followed by the health sciences model, and finally by the psychological model. This result supports previous literature claims indicating that an interdisciplinary approach offers more powerful explanations of social phenomena than unidisciplinary perspectives (Griffin, 2015; Godfrey & Torres, 2016). A situation that is especially clear in the case of the COVID-19 pandemic (Bontempi et al. 2020; Moradian et al. 2021).

Conclusions

From these results, it should be concluded that, despite less parsimony, the integrative interdisciplinary model is preferred over the alternative unidisciplinary ones. A caution note is necessary: this conclusion only applies to the context of this particular and (very) simple example. It does not imply that health science is better than psychology to explain engagement in precautionary measures against COVID-19 or any other infectious disease. A combination of alternative predictors could result in a reversal of the results. This combination could even produce the unexpected finding of a unidisciplinary model being preferred over the interdisciplinary one. Indeed, if the latter is not significantly different from the former (as indicated by the *diff. X^2* test), the unidisciplinary explanation should be selected as the best, since it is as powerful as the interdisciplinary but also more parsimonious.

Some limitations of the study must be mentioned. Since its main aim was to illustrate how a nested model approach can be utilized for specifying and testing an interdisciplinary model, no attempt was made to guarantee an adequate level of interdisciplinarity in semantics (concepts) and methods. A certain degree



of ambiguity may exist in “healthy actions” as belonging either (or both) to the field of the physical health sciences or to psychology, meaning that such concept could be used in both disciplines with no clear perceived boundary between them in utilizing this concept. Although this is not unexpected in interdisciplinary studies (Glänzel & Debackere, 2022), eliminating ambiguity as much as possible is recommended when trying to clarify the contribution of unidisciplinary elements to interdisciplinary studies.

Also, in both disciplinary models, just one (self-report) method was used, potentially limiting the methodological integration of disciplines. Given the serious situation imposed by COVID-19 at the beginning of the pandemic, the use of alternative measures to self-report (physiological tests and medical reports) resulted difficult so that this was the only available measure. Nonetheless, since the aim of the paper was to illustrate the use of a statistical technique (structural equations) for nesting models in interdisciplinary research, the focus was not on semantic or methodological integration (although its importance is not disdained).

By considering this proposal and the illustrative study’s limitations, the recommendations for prospective studies would include the following:

1. Conduct a bibliographic analysis of terms and methods contained in the unidisciplinary models, aimed at revealing the disciplinary specificity or singularity of concepts and techniques. This analysis would be useful in determining the specific contribution of every discipline and in eliminating ambiguities. Ways for conducting this analysis are included in Glänzel and Debackere (2022).
2. An interdisciplinary model is something more than the sum of unidisciplinary concepts and methods. Specify links between elements of particular disciplinary models, guided by theory and logic. Some clues for this are mentioned in point 4.



3. If possible, use a multi-method approach; this not only would decrease the interdisciplinary ambiguity of the integrative model, but also help in improving the construct validity of the study (see Corral-Verdugo & Figueredo, 1999).
4. With more than two disciplines, test hierarchically nested models, beginning with more “basic” disciplinary explanations and continuing with more molar models, as in a hierarchical multiple regression. For example, in a disciplinary study of interpersonal violence, the most basic model to be tested is a biological one (including genetic and neural influences), the second model would add a psychological approach (psychological traits) to the biological model, and a third model would include a sociological explanation (social models, social environment). As suggested here, each model could be tested independently, compete with each other and with the integrative hierarchically nested model. The approach allows estimating gains in explanatory power when adding one more disciplinary model; de Jong (1999) describes how a hierarchical regression analysis may be conducted with structural equations.

Of course, other analytical strategies could be followed using structural equation models and nested model comparisons, which were not covered in this paper. As well, additional strategies not considering the structural approach, like meta-analysis (Torka et al. 2021), multilevel analysis (Grabs et al. 2016), and systemic approaches (Yanitsky, 2020)—all of them applied to interdisciplinarity—could be taken into account.

Ethics statement

The studies involving human participants were reviewed and approved by the Comité de Ética en Investigación of the Universidad de Sonora (CEI-UNISON). The respondents provided their written informed consent to participate in this study.



Conflict of interest

No potential conflict of interest was reported by the author.

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