Conducting Mediation Analysis in Marketing Research

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Marketing researchers frequently conduct mediation analysis to enrich their understanding of a focal causal relationship by examining its underlying mechanism. The main purpose of this review is to provide an overview of what mediation analysis means, which approaches exist to establish mediation, and how to conduct mediation analysis with the state-of-the-art methodology. In the first part of the paper we review conceptual considerations of mediation for the most commonly used mediation model groups. We further discuss the suitability of different mediation analysis approaches, focusing on the bootstrapping approach. The second part of the paper is organized as a tutorial. Based on an example from the marketing field, we illustrate how to specify, estimate, and interpret mediation models with a tool for SPSS and SAS called PROCESS (Hayes 2017). We recommend a hierarchical procedure in which simple mediation models are examined first, followed by more complex models.

1. Introduction

Researchers in marketing and other fields are often interested in the causal effect of a predictor on an outcome variable. Mediation analysis adds to the understanding of such an effect by examining how well the effect can be explained by another variable, called a mediator (Iacobucci 2008). Thus, mediation analysis reveals how the predictor indirectly affects the outcome through the mediator. A prominent marketing example comes from research on advertising effectiveness, which revealed that the effect of ad liking on purchase intent is mediated by brand liking (MacKenzie et al. 1986). Mediation analysis is therefore especially relevant for those interested in grasping the underlying mechanism of a focal effect (Preacher 2015).

While common as a concept, an actual methodology of how to analyze mediation had not been established until Baron and Kenny (1986) proposed causal steps a researcher should apply to support a mediation hypothesis. The causal steps approach is based on the idea of inferring mediation from a series of separate regression models (Baron and Kenny 1986; James and Brett 1984; Judd and Kenny 1981). Another approach for analyzing mediation that was becoming increasingly popular at the time is structural equation modeling (SEM; Bagozzi and Yi 1988; Bollen 1989). Due to its ability to simultaneously...
estimate all model paths (Iacobucci et al. 2007), SEM is superior to the causal steps method. However, as its relative sophistication poses a number of problems and pitfalls (Anderson and Gerbing 1988), there have been calls for alternatives that are easy to use while also being equivalent to SEM.

Recent developments indicate that regression-based bootstrap approaches could be that alternative (Preacher and Hayes 2004, 2008). In particular, sophisticated mediation analysis has been simplified by Hayes’ provision of the mediation analysis macro PROCESS, which is available for SPSS and SAS (Hayes 2017), as well as the accompanying textbook (Hayes 2013). Due to these advances, regression-based mediation analysis now allows the same reliability in estimation as SEM does (Hayes and Scharkow 2013). Therefore, applications of regression-based mediation analysis with novel methodology (Hayes 2013; Preacher and Hayes 2004, 2008) have been garnering increasing interest. The growing number of citations of the respective methodology papers reflects the relevance of mediation analysis as a means of theory development and testing in marketing research (see Fig. 1).

Fig. 1 displays how many times the most influential mediation publications (i.e., Baron and Kenny 1986; Hayes 2013; Preacher and Hayes 2004, 2008; Sobel 1982) have been cited in the top-tier marketing outlets Journal of Consumer Research, Journal of Consumer Psychology,[1] Journal of Marketing, Journal of Marketing Research, and Marketing Science since the publication of Baron and Kenny’s (1986) causal steps approach. As can be seen from Fig. 1, interest in mediation analysis has increased substantially in the last decade.

Although there is now a well-established body of literature advancing the methodology of mediation analysis since Baron and Kenny (1986), this technical literature has not fully “diffused to practicing researchers” (Zhao et al. 2010, p. 197). As a result, researchers often diverge in how they conduct tests of mediation (Hayes and Scharkow 2013). This paper contributes to existing literature by concisely integrating theoretical and practical knowledge in order to help in applying mediation analysis. Our main goal is to provide an overview of what mediation analysis means and which approaches exist to establish mediation, followed by a tutorial that demonstrates how to apply the state-of-the-art methodology. In the tutorial we illustrate how to specify, interpret, and report results using PROCESS (Hayes 2017). The analyses are conducted with examples from the marketing context.

2. Characteristics of mediation

Central to the concept of mediation is the so-called mediator. Extending a simple causal inference where a predictor X causes an outcome Y, the mediator M intervenes within this relationship. A mediator M is therefore a variable that is influenced by the predictor X and in turn influences the outcome Y. \(X \rightarrow M \rightarrow Y\). When conducting mediation analysis, the researcher is primarily interested in this intervention process, namely the indirect effect, because it reveals something about how the causal relationship works (Iacobucci 2008). Therefore, examining the indirect effect is the focal element of theory testing with mediation analysis (Hayes 2013).

However, to estimate the extent to which the mediation process explains the relationship between the predictor X and the outcome Y, it is also necessary to consider the so-called direct effect. The direct effect represents the causal influence of X on Y that is not explained by the mediator M (James and Brett 1984). As we will outline in Section 2.3, examining the direct effect is particularly useful for further theory building (Zhao et al. 2010).

2.1. Indirect effect: Key to establishing mediation

In a first step, a researcher is often interested in whether a proposed mediator M can explain an effect of X on Y at all. This question is addressed by estimating the indirect effect through the mediator M (Hayes 2013). Hence, interpreting the indirect effect is the foundation for inference about a mediation hypothesis (Baron and Kenny 1986). In the following, we discuss how the indirect effect can be interpreted. It is important to note that the interpretation of the indirect effect is dependent on the model structure, especially the number of variables in the model and their interrelationships. While there is a multitude of possible mediation models, in this paper we focus

Fig. 1: Citation trend of influential mediation analysis publications

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on four prototype model groups (Hayes 2013). Three of these model groups entail mediation only; hence we refer to them as models of “pure” mediation: (i) simple mediation, (ii) parallel mediation, and (iii) serial mediation. Aside from these “pure” mediation model groups, there are models that additionally contain moderator variables, referred to as moderated mediation models. Fig. 2 illustrates the prototype model groups.

Simple mediation captures the standard $X \rightarrow M \rightarrow Y$ causal system, which means that there is exactly one mediator. In case of two or more mediators in the model, one can speak of multiple mediation (Hayes 2013). If the multiple mediators are causally unrelated, this is called parallel mediation, while serial mediation is present if at least two of the mediators in the model are causally related (i.e., one mediator affects another one and they form a causal chain). Moderated mediation means that at least one mediation path is linearly dependent on another variable. Each mediation model group is discussed in greater detail in the following section.

2.1.1. Simple mediation

Mediation extends simple regression by introducing an explaining variable, the mediator (see Fig. 3). When there is exactly one mediator $M$ intervening in the causal relationship of $X$ on $Y$, this is called simple mediation. Conceptually, simple mediation means that a change in $X$ leads to change in $M$ (path $a$), and that change in $M$ leads to change in $Y$ (path $b$). The indirect effect is depicted as path $ab$ because it is the product of the two paths that connect the predictor $X$ to the mediator $M$ (path $a$) and the mediator $M$ to the outcome $Y$ (path $b$). If the indirect effect $ab$ is greater or smaller than zero (i.e., if it is statistically significant), one can claim that some form of mediation takes place (Zhao et al. 2010).

Simple mediation is the most basic form of mediation and allows one to make inferences about the underlying mechanism that connects an independent with a dependent variable. If the underlying process involves more than one mediator, so-called multiple mediation models are used. We discuss two forms of multiple mediation – parallel and serial mediation – in the following sections.
Parallel mediation models enable researchers to probe different mediation theories simultaneously in a model (e.g., Guevarra and Howell 2015). The example of two mediators would lead to a conceptual model structure like the one shown in Fig. 4.

\[ a_1b_1 + a_2b_2 \]

Fig. 4: Parallel mediation model with two mediators (based on Hayes 2013, p. 126)

In models with more than one mediator, several specific indirect effects exist that can be attributed to one of the mediators. In the example displayed in Fig. 4, there are two specific indirect effects \( a_1b_1 \) and \( a_2b_2 \). If the aim of the researcher is to compare these two mediation processes, it is useful to assess the importance of each specific indirect effect. To do so, the researcher could check which of the proposed parallel mediations (i.e., specific indirect effects) is significant and then compare the magnitude of those specific indirect effects by testing whether they are equal in size (Preacher and Hayes 2008).

All specific indirect effects sum up to the total indirect effect, which expresses the extent to which all mediators together can explain the relationship between \( X \) and \( Y \). We note that there are cases in which specific indirect effects with different signs cancel each other out, leading to an insignificant total indirect effect, despite having significant specific indirect effects (Rucker et al. 2011). Such a finding would be valuable, as it identifies two antagonistic mechanisms and thus offers deeper insight into the relationship between \( X \) and \( Y \) (Hayes 2009). This implies that finding a non-significant total indirect effect does not automatically mean that the conceptual model is flawed.

2.1.3. Serial mediation

Whenever the researcher hypothesizes that two or more mediators in a model influence each other, this is called serial mediation. In contrast to parallel mediation, serial mediation means that the mediators themselves are in a hierarchical causal relationship. Serial mediation is especially useful for investigating fine-grained causal chains of mediation (Hayes 2013) and is commonly employed in the marketing field (e.g., Hur et al. 2015; Winterich and Zhang 2014). Fig. 5 depicts an example in which one mediator affects another mediator.

Similarly to parallel mediation, the indirect effect in a serial mediation model is split up into several specific indirect effects. In the two-mediator example, three specific indirect effects can be distinguished. First, there is the long-way mediation, which involves both mediators: \( a_1db_2 \). The long-way mediation represents a causal chain of mediators and is therefore the foundation of the serial mediation hypothesis. Second, there are two shortcut mediations, which each involve only one mediator: \( a_1b_1 \) and \( a_2b_2 \). If the long-way mediation is significant, serial mediation can be claimed. If the long-way mediation is not significant, this indicates that one of the other forms of mediation is more likely: if both shortcut mediations are significant, this indicates parallel mediation (as in Fig. 4); and only one significant shortcut mediation indicates simple mediation (as in Fig. 3). As in parallel mediation, the sum of all indirect effects constitutes the total indirect effect. The total indirect effect indicates the extent to which the long-way and all shortcut mediations together explain the effect of \( X \) on \( Y \).

\[ a_1db_2 + a_1b_1 + a_2b_2 \]

Fig. 5: Serial mediation model with two mediators (based on Hayes 2013, p. 145)
As moderated mediation is about inferring whether an indirect effect is linearly conditioned by a moderator, the most central result of such a model would be the so-called conditional indirect effect of X on Y (Iacobucci 2008). Although many authors have conceptually referred to moderated mediation (Baron and Kenny 1986; James and Brett 1984; Muller et al. 2005), an appropriate procedure for examining a conditional indirect effect was offered only recently (Hayes 2015). The procedure involves a formal test of the conditional nature of proposed mediators called the index of moderated mediation (Hayes 2015).

2.2. Direct effect: Key to assessing the importance of the mediation

While a significant indirect effect of X on Y through M answers the question of whether a proposed mediation exists, a researcher might also be interested in understanding to what extent the mediator can explain the relationship between X and Y (Rucker et al. 2011). In mediation analysis, this is determined by the direct effect of X on Y, which represents the influence of X on Y that is unrelated to change in M. Given a significant indirect effect but an insignificant direct effect, the mediation fully explains the variation of Y by X. In this case, researchers speak of full mediation (Baron and Kenny 1986; Zhao et al. 2010). However, if the direct effect is significant, the mediator M only partially explains the effect of X on Y and the term partial mediation is used (James and Brett 1984; Zhao et al. 2010). While some authors claim full mediation to be the gold standard, most articles that use mediation analysis report only partial mediation (Iacobucci 2008). In the following, we examine how distinguishing partial from full mediation may offer implications for theory building.

2.3. Mediation types and their implications for theory building

Zhao et al. (2010) developed a typology of mediation based on the interpretation of the indirect and direct ef-

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**Fig. 6: Selection of variants of a moderated mediation model (own illustration based on Hayes 2013, p. 14)**
Is indirect effect significant? Yes
Is direct effect significant? No
Do indirect and direct effect have opposing signs? No

**Results Consistent with Proposed Framework?**
- Yes
- Yes
- No
- No

**Likely to Find an Omitted Mediator?**
- No
- Yes

**Most Likely Sign of this Omitted Mediator?**
- Same sign as the existing mediator
- Opposing sign to the existing mediator
- Same sign as the direct effect

**Fig. 7: Mediation types and their implications for theory building (own illustration based on Zhao et al. 2010, p. 201)**

An insignificant indirect effect suggests non-mediation (Zhao et al. 2010). In this case, the same conclusions as before apply: if the direct effect is significant, there is a chance that the true mediator has been omitted. We note that in such a case, examination of paths $a$ and $b$ is particularly informative. If path $a$ or $b$ is not significant or very small in magnitude, this could explain the insignificance of the indirect effect as a whole, and it can guide future modification of the inconsistent conceptual framework. If both the indirect and direct effects are insignificant, $X$ and $Y$ are apparently unconnected.

### 3. Approaches to examine mediation

In the marketing field there are three dominant approaches to examining mediation: the *causal steps method* proposed by Baron and Kenny (1986), the *normal theory approach* introduced by Sobel (1982, 1986), and the regression-based *bootstrapping approach* put forth by Preacher and Hayes (2004, 2008). While the first two approaches are often used in conjunction and represent the traditional way of testing for mediation, bootstrapping is a more recent approach in mediation analysis.

#### 3.1. Traditional approaches

Traditionally, the most influential approach in probing mediation has been the causal steps approach. Though Judd and Kenny (1981) as well as James and Brett (1984) already discussed the technique, it was finally proposed by Baron and Kenny (1986) and is therefore known as the *Baron-and-Kenny approach* (Kenny 2008). The basic principle of the causal steps approach is that it does not test the indirect effect itself, but logically infers mediation from testing all paths of the model separately.
in four steps (Baron and Kenny 1986).[2] The approach involves analyses of (i) the total effect of X on Y, (ii) the effect of X on M, (iii) the effect of M on Y, and (iv) the direct effect of X on Y (see Tab. 1). Baron and Kenny (1986) propose that one can only claim mediation if all effects in the first three steps turn out to be significant. Given this prerequisite, one can claim full mediation if the direct effect in the fourth step is non-significant and partial mediation if it the direct effect is smaller than the total effect.

The Baron-and-Kenny approach has been criticized for several reasons. The most critical issues are its lack of power (which means that it often cannot uncover a genuine mediation process) as well as its failure to test the indirect effect \( ab \) (Hayes 2013; MacKinnon et al. 2002; Preacher and Hayes 2004, 2008). In addition, the requirements for steps (i) and (iv) seem overly restrictive and are unnecessary for establishing mediation (Hayes 2009; Rucker et al. 2011; Zhao et al. 2010). Due to these limitations, the Baron-and-Kenny approach no longer seems to be recommended (Hayes 2013; MacKinnon et al. 2002).

The normal theory approach (Sobel 1982, 1986), also called the Sobel test, addresses one weakness of the Baron-and-Kenny approach by establishing a formal test of the indirect effect \( ab \). The Sobel test uses a logic for the inference of the indirect effect similar to that usually used for the estimation of direct effects. To conduct the test, one calculates the product of the coefficients \( a \) and \( b \), divides this product by an estimate of the standard error of \( ab \), and compares this empirical z-score to a critical value from the standard normal distribution (Sobel 1982):

\[
Z = \frac{ab}{se_{ab}} \tag{1}
\]

Several methodological variations of the Sobel test exist, each varying in the way that \( se_{ab} \) is estimated. The simplest estimation approach (Baron and Kenny 1986; Sobel 1982), also referred to as first-order delta solution, encompasses the squared coefficients \( a \) and \( b \) and their squared standard errors:

\[
se_{ab} = \sqrt{a^2 se_a^2 + b^2 se_b^2} \tag{2}
\]

More complex estimation approaches include an additional product term of both squared standard errors, with this term either added to Equation (2) (Aroian 1947; so-called second-order delta solution) or subtracted (Goodman 1960; so-called unbiased delta solution). As all methods yield very similar results (Hayes and Scharkow 2013; MacKinnon et al. 1995), the simple first-order delta solution seems to be the most straightforward approach. Nevertheless, the following remarks hold for all variants of the Sobel test.

The Sobel test’s shortcomings result from its normality assumption of the sampling distribution in the indirect effect \( ab \). This assumption is usually only met in very large sample sizes (i.e., \( n > 1,000 \); Kisbu-Sakarya et al. 2014), while in smaller samples the sampling distribution of \( ab \) tends to be asymmetric (Bollen and Stine 1990; Stone and Sobel 1990). Although this limitation becomes less problematic with increasing effect sizes (e.g., a sample size of \( n = 100 \) seems sufficient to detect medium-sized mediation effects; MacKinnon et al. 2002), the Sobel test has specific weaknesses in detecting mediation when either path \( a \) or path \( b \) is weak. Therefore, the Sobel test has low power in detecting indirect effects and thus tends to be overly conservative. This means that the Sobel test might indicate that there is no indirect effect, while in reality there is mediation (Shrout and Bolger 2002). Hence, there is some risk of overlooking a genuine indirect effect in the data when using the Sobel test, unless the effect size or sample size is large (for details regarding mediation effect size and required sample size, see Fritz and MacKinnon 2007). Due to these limitations, use of (any variant of) the Sobel test is no longer recommended (Hayes and Scharkow 2013).

3.2. Bootstrapping approach

Bootstrapping is a non-parametric approach that bypasses the problem of questionable distributional assumptions of traditional techniques and enables an accurate test of the indirect effect (Bollen and Stine 1990; Shrout and Bolger 2002), even in small samples (Preacher and Hayes 2008). Importantly, bootstrapping provides more power in detecting indirect effects, but it does not show a higher type-I-error tendency (i.e., claiming me-
Bootstrapping relies on resampling of the data (Efron 1982), whereby one draws a large number (e.g., 10,000) of new samples of size \( n \) with replacement from the original sample. The model parameters are estimated for each new sample, resulting in a large number of estimates for each parameter. The estimates can then be ordered by size to draw a probability density distribution for each path parameter (Preacher and Hayes 2004).

Fig. 8 shows a hypothetical example for such a density distribution of the indirect effect \( ab \).

The mean of all bootstrap estimates is calculated for the point estimate of the indirect effect \( ab \) (see Fig. 8). Because a non-normal distribution of parameters precludes the calculation of \( t \)- and \( p \)-values, the significance of the indirect effect \( ab \) is inferred from the confidence interval of its bootstrap distribution. If the confidence interval does not include zero, one can be statistically confident that the effect is different from zero.

In the basic form, called percentile bootstrap, the confidence interval is determined by two percentile cutoffs of the sampling distribution (e.g., 2.5% and 97.5% in the case of \( \alpha = .05 \)). In the example of 10,000 bootstraps illustrated in Fig. 8, the 250th highest (.05) and 9751st highest score (.50) define the 95% confidence interval. The results of the percentile bootstrap in Fig. 8 indicate that the proposed indirect effect is significantly different from zero, as the confidence interval does not include zero (meaning it does not encompass positive and negative values). Therefore, one can say with 95% confidence that mediation is present (Preacher and Hayes 2004).

The percentile bootstrap is especially suitable in circumstances where robustness of the estimation is important, such as when samples include potential outliers (Creedon and Hayes 2015), when either the \( a \) or \( b \) path is large and the other path is zero (Koopman et al. 2015), or when facing small sample size \( (n < 50; \text{Koopman et al. 2015}) \). In case of larger sample sizes it is recommendable to use an alternative form called bias-corrected bootstrap. This procedure generally results in slightly more liberal bootstrap confidence intervals because it adjusts the confidence interval for bias in the bootstrap sample distribution (Efron 1987). Such bias may result from non-symmetric bootstrap sample distributions and is not accounted for by the percentile bootstrap (Efron and Tibshirani 1993). The differences across forms of bootstrapping are usually small, but they can sometimes influence the inference. While percentile bootstrapping may be reasonable in adverse situations (such as small sample size), bias-corrected bootstrap today is the standard form in mediation analysis.

Although percentile bootstrap and bias-corrected bootstrap differ slightly in their estimates, both outperform the Sobel test and Baron-and-Kenny approach remarkably with regard to statistical power (Hayes and Scharkow 2013) and propensity to type I error (MacKinnon et al. 2002). Hence, among the methods that are commonly used, reliable, and easy to conduct, bootstrapping seems to be the most promising approach for mediation analysis. After two seminal papers and add-ons about the bootstrapping approach in mediation analysis (Preacher and Hayes 2004, 2008), Hayes (2013, 2017) released a macro for SPSS and SAS called PROCESS, which combines the functionality of the preceding add-ons. In the following, we demonstrate how to conduct and interpret mediation analysis following the bootstrapping approach with PROCESS. The tutorial illustrates the specification of the different model groups and the interpretation of respective results with an example from advertising effectiveness.

4. Tutorial: Estimating mediation models with PROCESS

PROCESS (which can be downloaded from the developer’s website; Hayes 2017) is specialized for mediation analysis, moderation analysis, and combinations of both procedures using the regression-based bootstrapping approach. PROCESS provides a dialog box-style graphical user interface as well as a syntax-based form, which makes it easy for researchers to specify and estimate models. The macro works with predefined models numbered from model 1 to model 76, all assigned to one special conceptual structure of the focal mediation model and thus enabling it to estimate the most commonly used theoretical model structures. [3] PROCESS requires
are potentially important for the underlying process, namely attitude toward the brand ($A_{Brand}$), product recall (recall), and the elaboration of the ad (elabo). All variables were measured on 7-point Likert scales (with 7 = “completely agree”), except elabo which was experimentally manipulated (with the levels 1 = high and 2 = low). Finally, the data set includes the control variable age. With these variables, we will provide guidance on how to interpret the PROCESS output; suggestions for reporting results for each of the four mediation models are summarized in the appendix.

4.1.1. Simple mediation

First, we might be interested in answering the question of whether $A_{Brand}$ mediates the effect of $A_{Ad}$ on PI. This corresponds to a simple mediation model, as proposed by MacKenzie et al. (1986) and illustrated in Fig. 10.

Translating the simple mediation model to PROCESS means that we have to choose the model number 4 in the PROCESS template (see Hayes 2013) and specify the necessary variables. The associated syntax command must be specified as follows:[5]

```
process vars = A_Ad A_Brand PI/y = PI/x = A_Ad/m = A_Brand/model = 4.
```

The syntax command first defines that the procedure “process” shall be used. Next, after the “vars =” argument, all model variables are listed and assigned to their roles as $X$, $M$, or $Y$ in the model. The final specification assigns the appropriate model number, “/model = 4.” After running the syntax, PROCESS generates an output, which is divided into different sections, separated by lines of stars (see Fig. 11).

Just below the header, the model specification and sample size is presented. The second and third sections plot the simple regression results for paths $a$ and $b$, respectively. The section 4, titled “Direct and indirect effects,”

Fig. 9: Screenshot of the PROCESS v 2.16 graphical user interface in IBM SPSS Statistics 24

Fig. 10: Simple mediation example (PROCESS model 4)
is the central part of the mediation analysis output. The last section entails information about the number of bootstrap samples and the level of confidence for all confidence intervals reported in the output.

We can determine whether mediation exists by interpreting the indirect effect of \( A_{Ad} \) on \( PI \) through \( A_{Brand} \) (depicted in the output section 4 as “indirect effect \( ab \)”). Using the bootstrap sample distribution explained above (see Section 3.2.), PROCESS reports the point estimate of the indirect effect (“Effect”) and its standard error (“Boot SE”). This is followed by the upper and lower limits of the bootstrap confidence interval (“BootLLCI” and “BootULCI”). As can be seen from the output, the bootstrap confidence interval (CI) is (.16 to .49). As the 95% confidence interval does not include zero, we can infer significant mediation of \( A_{Ad} \)’s effect on \( PI \) through \( A_{Brand} \) at \( \alpha = .05 \). Next, the importance of the mediation can be assessed by interpreting \( A_{Ad} \)’s direct effect on \( PI \) (depicted as path \( c' \)). In the example, the \( p \)-value of the direct effect is .047 and can therefore be considered significant. Using the framework depicted in Fig. 7, we can conclude complementary partial mediation (Zhao et al. 2010). In addition to the direct and indirect effects of the independent variable, PROCESS plots the estimates for the single paths of the model. For the simple mediation model, these can be derived from the results of two regressions underlying the model: one having mediator \( A_{Brand} \) and one having \( PI \) as outcome variable. As the indirect effect consists of two single effects, path \( A_{Ad} \rightarrow A_{Brand} \) and path \( A_{Brand} \rightarrow PI \), one can inspect them to reveal that attitude toward the ad impacts purchase intent because it in-
increases attitude toward the brand (effect: .49, p < .001; depicted as path $a$), while the latter increases purchase intent (effect: .63, p < .001; depicted as path $b$). Note that the point estimate of the indirect effect $ab$ equals the product of $a \times b$: $c' = .49 \times .63$.

4.1.2. Parallel mediation

Extending the simple mediation situation, recall could be another potential mediator between $A_{Ad}$ and PI (Brown and Stayman 1992), which would lead to a conceptual model structure like the one shown in Fig. 12.

When comparing two proposed mediations it may be of interest to assess whether the corresponding specific indirect effects differ in magnitude. In PROCESS, the "contrast test" command provides a significance test that can carry out this comparison. If enabled, PROCESS estimates bootstrap confidence intervals for a pairwise comparison of specific indirect effects. It is expressed by a confidence interval because it is based on the bootstrap sampling distributions of both specific indirect effects. If the confidence interval does not entail zero, it implies that the two specific indirect effects are statistically different from each other (if it does include zero, difference between the effects cannot be assumed). It is important to note that this test can only be interpreted as a comparison of effect size when both effects have the same sign. Compared to the simple mediation example, the syntax command is changed in two ways. First, the variable recall is entered and assigned the role of (second) mediator ("m = recall"). Second, the pairwise comparison option for the specific indirect effects is enabled with "contrast = 1."

The PROCESS output summary in Fig. 13 looks similar to the one-mediator case in Fig. 11. However, in this model there are now two specific indirect effects ($A_{Ad} \rightarrow A_{Brand} \rightarrow PI$ and $A_{Ad} \rightarrow recall \rightarrow PI$), which together constitute a total indirect effect. For the parallel mediation model, it is most important to interpret these specific indirect effects. In our example, $A_{Brand}$ (indirect effect: .26; 95 % CI: .14 to .43) as well as recall (indirect effect: .08; 95 % CI: .02 to .17) are significant mediators. If a comparison of the two indirect effects is intended, the contrast bootstrap interval (see line C1, which means "contrast 1") is examined (depicted as contrast test). In the example, two positive mediations coexist in parallel and differ significantly in size, as the C1 bootstrap confidence interval does not encompass zero (difference: .17; 95 % CI: .01 to .36). This means that $A_{Brand}$ can explain the effect of $A_{Ad}$ on PI significantly better than recall does. Finally, the total indirect effect should only be interpreted if the researcher wants to investigate the extent to which all mediators together can explain the causal relationship between $A_{Ad}$ and PI (depicted as total indirect effect). In the example, the total indirect effect is positive and significant (effect: .34; 95 % CI: .20 to .50). Next, we can interpret the direct effect (depicted as path $c'$). As the effect is insignificant (effect: .12; p = .075), we can infer full mediation (see Fig. 7).[6] It can also be an option to further investigate the detailed regression results (as in the previous section), but we do not illustrate this here.

Taken together, the analysis reveals that attitude toward the ad impacts purchase intent through both attitude toward the brand as well as product recall. However, the indirect effect through attitude toward the brand is greater in magnitude than that through product recall. This indicates that attitude toward the brand plays a greater role in explaining the effect of attitude toward the ad than product recall does.
4.1.3. Serial mediation

Transferring the perspective of serial mediation to our example, one can also hypothesize that the two mediator variables, $A_{\text{Brand}}$ and recall, are causally related. One plausible assumption could be that $A_{\text{Brand}}$ impacts recall (Brown and Stayman 1992), which would result in a conceptual model like the one depicted in Fig. 14.

When specifying serial mediation with model 6, it is particularly important to consider the order of the mediator variables in the “$m =$” list, as the variables listed earlier will be regarded causally prior to those listed later. We note that in our example no adjustment of the mediator order is necessary as it already complied with the proposed causal chain. Specifying the framework thus requires two changes to the parallel mediation syntax command: First, the model number must be changed to “model = 6.” Second, the “contrast = 1” option is no longer necessary, as the aim of serial mediation is not to compare the mediators. These changes result in the following model specification:

```
process vars = A_Ad A_Brand PI recall/y = PI/x = A_Ad/m = A_Brand recall/model = 6.
```

Again, the most important part of the output is the summary section ("Direct and indirect effects"), displayed in Fig. 15. PROCESS plots each specific indirect effect as well as the total indirect effect. Central to the serial mediation hypothesis is the long-way mediation $A_{\text{ad}} \rightarrow A_{\text{Brand}} \rightarrow \text{recall} \rightarrow PI$ (named “Ind2” in the output). If the long-way specific indirect effect is significant, serial mediation can be claimed (depicted as long-way specific indirect effect $a_1db_2$). Second, we investigate the shortcut indirect effects (depicted as shortcut specific indirect effects $a_1b_1$ and $a_2b_2$) and the direct effect (depicted as path $c'$) to better understand the character of the proposed mediation paths. As before, it can also be an option to further investigate the detailed regression results (which are not illustrated here).

The output of the example in Fig. 15 suggests that the long-way mediation $A_{\text{ad}} \rightarrow A_{\text{Brand}} \rightarrow \text{recall} \rightarrow PI$ is significant (effect: .05; 95% CI: .02 to .11), as is the indirect path $A_{\text{ad}} \rightarrow A_{\text{Brand}} \rightarrow \text{recall} \rightarrow PI$ (effect: .25; 95% CI: .13 to .41). In contrast, the indirect effect of $A_{\text{ad}} \rightarrow \text{recall} \rightarrow PI$ is not significant (95% CI: -.04 to .12). Like in the parallel mediation example, the direct effect is insignificant ($p = .075$). Taken together, the data support the serial mediation hypothesis: attitude toward the ad increases attitude toward the brand, which in turn increases product recall, which ultimately affects purchase intent. In addition, attitude toward the ad affects purchase intent via attitude toward the brand, without product recall being involved. This finding qualifies the result of the parallel mediation example: product recall does not act as an independent mediator but rather is part of a

- $A_{\text{ad}}$: predictor variable
- $A_{\text{Brand}}$: mediator 1
- recall: mediator 2
- PI: outcome variable
- $a_1db_2$: long-way specific indirect effect of $A_{\text{ad}}$ on $PI$ through $A_{\text{Brand}}$ and recall
- $a_1b_1$: shortcut specific indirect effect of $A_{\text{ad}}$ on $PI$ through $A_{\text{Brand}}$ only
- $a_2b_2$: shortcut specific indirect effect of $A_{\text{ad}}$ on $PI$ through $recall$ only
- $c'$: direct effect of $A_{\text{ad}}$ on $PI$

The total indirect effect is $a_1db_2 + a_1b_1 + a_2b_2$.

**Fig. 14: Serial mediation example (PROCESS model 6)**

**Fig. 15: PROCESS output summary of serial mediation example (model 6)**
4.1.4. Moderated mediation

Extending the “pure mediation” example, one could imagine that the test person’s processing elaboration of the ad (elabo) might be a variable that determines whether the proposed mediation process $A_{Ad} \rightarrow A_{Brand} \rightarrow PI$ exists. Specifically, it is conceivable that in the case of low elaboration the proposed mediation works, while $A_{Ad}$ does not lead to an increase in $A_{Brand}$ in case of high elaboration (MacKenzie and Spreng 1992). In this case a first-stage moderated mediation model in PROCESS is suitable, as shown in its most basic form (model 7) in Fig. 16.

To specify such a model in PROCESS, one must adjust the syntax command of the simple mediation model to include the variable elabo and assign it the moderator role with “/w = elabo.” Moreover, the model number must be changed to “model = 7.”

The output shown in Fig. 17 provides a summary of the direct and indirect effects. The indirect effect is now conditional on the values of the moderator (the subsection is therefore called “Conditional indirect effect(s) of X on Y at values of the moderator(s)”).

To interpret the output, it is necessary to examine whether the proposed moderated mediation exists. This can be achieved by carrying out a formal test of moderated mediation called the index of moderated mediation (Hayes 2015), depicted as such in Fig. 17. The index represents the quantification of the linear association between the moderator and the indirect effect. Like before, it is a bootstrap confidence interval that is interpreted as support for the existence of moderated mediation if it does not include zero. As here the confidence interval does not include zero (95 % CI: .06 to .63), the hypothesis of moderated mediation is supported. This means that the indirect effect of $A_{Ad}$ on $PI$ through $A_{Brand}$ depends on levels of elabo.

If the index of moderated mediation supports the existence of moderated mediation, one may wish to investigate the indirect effect at representative values of the moderator (depicted as conditional indirect effect) to further explore the conditions under which mediation does (not) exist (Preacher et al. 2007). This method is also called spotlight analysis (Fitzsimons 2008; Spiller et al. 2013). If the moderator is dichotomous, it results in exactly two conditional indirect effects. For a continuous moderator, by default the conditional indirect effects for the moderator mean and at values of one standard deviation above and below the mean are plotted. As in the examples before, the mediation type can be determined by additionally considering the direct effect (depicted as path $c’$). In the example we see that while there is a significant indirect effect for test persons with low elaboration (effect: .45; 95 % CI: .24 to .66), the effect is not significant in the high-elaboration group (95 % CI: -.07 to .34). The direct

conditional indirect effect:
indirect effect ab, conditional on levels of elabo
being high (1) or low (2)

Fig. 16: Moderated mediation example (PROCESS model 7)

Fig. 17: PROCESS output summary of moderated mediation example (model 7)
Control for the influence of other variables in the model by including covariates

Make bootstrap results reproducible and avoid variances in results due to resampling when repeating the same analysis

Make the estimation of confidence intervals more precise

Change the bootstrapping approach from the default bias-correct bootstrap to percentile bootstrapping

Save the estimated bootstraps of all paths of the model in a new SPSS data set to compare confidence intervals of parameters, for example.

Perform mediation analysis with a multycategorical independent variable (e.g., two experimental conditions plus a control group coded “1 = control,” “2 = treatment A,” and “3 = treatment B”)

Listing variables after “process vars =” without assigning roles makes PROCESS treat these variables as covariates.

PROCESS output values always differ slightly due to the random resampling process. The statement is seeding the random number generator responsible for resampling with an arbitrary value, which leads to exactly reproducible results.

5,000 bootstrap resamples is the default in PROCESS. The higher the number of bootstraps, the more reliable the results become. 10,000 bootstraps are a good compromise between desired precision and required computation time.

Percentile bootstrapping is especially robust in small samples or adverse situations.

Saving the bootstraps makes it possible to manually compare paths or function of paths (e.g., the indirect effect is a function of a and b). In the new data set, each row contains the coefficients from one bootstrap sample (e.g., i1, a, i2, b, c’ for the simple mediation model named COL1 to COL5).

Unlike continuous or dichotomous variables, multycategorical independent variables cannot just be included in mediation analysis without transformation (categorical independent variables with more than two levels are interpreted as linear, which leads to biased parameter estimates). PROCESS is able to recode such a multycategorical variable automatically via the command “/mcx = ”, with “/mcx = 1” being the flag for dummy coding (for a detailed description of the analysis, see Hayes and Preacher 2014). Note that multycategorical independent variables are currently possible in simple mediation models only.

5. Robustness assessment and complex model testing

In the last section, we examine two topics worth considering for a deeper understanding of how to conduct mediation analysis. Although there have been many advanced topics discussed in the recent literature, such as how to handle longitudinal data (Preacher 2015) or analyzing non-linear effects (Hayes and Preacher 2010), we limit the scope of this section to two basic topics: (i) the importance of making robust causal inference via correct specification and (ii) the use of structural equation modeling as an alternative for analyzing complex mediation models.

5.1. Assessing the robustness of the causal inference

As discussed in the context of partial mediation, a rigorous specification of the proposed model is of utmost importance in order to identify genuine mediation processes. We also examined the omitting of alternative moderators or mediators as examples of incomplete mediation findings. However, there are further misspecifications that could turn a genuine full mediation into a result of
partial mediation or insignificance, such as non-linearity of causal relationships, measurement error, missing paths, or outliers (Creedon and Hayes 2015). To overcome these potential sources of misspecification, the standard means known from regression analysis should be applied (e.g., visual inspection, outlier detection, inspection of residuals).

Even in the case of a significant full mediation, the researcher should reflect upon the specification of the proposed model to ensure that the results are meaningful. If this is not done carefully, what has been identified as a mediator in the proposed model might in reality play a different causal role (MacKinnon et al. 2000; Stelzl 1986). For example, the proposed mediator $M$ may not be a real causal mediator, but rather just a correlate of $X$, $Y$, or the true mediator that is not specified in the model at all. Therefore, inference about the proposed mediation cannot be based on a significant indirect effect alone; instead, significance of the mediation is just a necessary condition following a-priori conceptual reasoning (Fiedler et al. 2011). It is therefore important to make sure that one can conceptually and empirically justify the proposed model against rival explanations (Iacobucci et al. 2007). In this regard, it makes sense to test other possible model specifications and compare them to the focal model (and report the results accordingly). If one can rule out the potential sources of misspecification discussed above, this enhances confidence in the proposed theoretical framework.

It is important to note that there are no formal means of examining the fit of a model (like the multiple fit indices known from SEM; see Section 5.2.) when using PROCESS. In situations where more than one model is both conceptually and empirically meaningful (e.g., significant and interpretable indirect effects in parallel and serial mediation analysis), we follow Hayes (2013) and recommend preferring those models which are less restricted in their assumptions. In the given example, this would mean preferring the serial model over the parallel model, as it allows both mediators to be connected, while the parallel model implicitly assumes that the mediators are unrelated (i.e., a correlation of exactly zero).

5.2. Testing complex mediation models with SEM

In this paper we have illustrated how to use regression-based mediation analysis via PROCESS for moderately complex mediation models. This approach is sufficient for most research settings, as simpler models with fewer variables are generally preferable to more complex ones (Cohen 1990). However, there might be situations that require complex mediation models that cannot be analyzed with PROCESS. For example, a requested model may contain more than one independent or dependent variable.

SEM offers a methodology for analyzing causal relationships between multiple latent variables (Bollen 1989; Iacobucci 2010). Hence, SEM allows the examination of complex nomological networks (Iacobucci 2008), such as serial mediation models with multiple dependent and independent (in SEM terminology: exogenous) variables. In addition to the number of structural relationships, SEM is also flexible regarding the type of relationships. For example, it is possible to model non-recursive relations of the form $Y_1 \leftarrow Y_2$ (Iacobucci 2009).

Another advantage of SEM is that it explicitly considers latent variables with multiple indicators that are measured with error, whereas in regression-based research multi-item measurements of variables are typically collapsed to mean scores (Iacobucci 2009). If the items measure the latent construct inconsistently (i.e., factor loadings are not uniformly high), this simplification can reduce the likelihood of finding systematic relationships in regression-based mediation analysis (Danner et al. 2015). Iacobucci et al. (2007) demonstrate that inferring mediation from mean scores for $X, M, \text{and} Y$ may lead to misleading results compared to full measurement models, especially when the mediation effect is small. In conclusion, it may be beneficial to consider measurement error if the measurement of variables is problematic (which can be identified via factor analysis or reliability analysis).

A third advantage of SEM is its provision of model fit indices (Hu and Bentler 1998; Iacobucci 2010). Fit indices can be used to assess the adequacy of a proposed model, but they also enable the comparison of different models. Formal comparison is useful because sometimes a researcher is unsure which theoretical model is most promising. For instance, the so-called $\chi^2$ difference test is able to test whether two nested models significantly differ; the better fitting model is indicated by the smaller $\chi^2$ value (for details on model comparison, see Danner et al. 2015). Furthermore, SEM allows one to constrain paths inside the structural model if there is theoretical reason to do so (e.g., to set them to zero or to set several paths to the same value). Such constrained models can also be compared to more parsimonious alternatives via fit indices that take into account the parsimony of the models (e.g., Bayesian Information Criterion; see Danner et al. 2015).

In the case of models that cannot be specified with PROCESS, using established SEM software like AMOS (Arbuckle 2016) or Mplus (Muthén and Muthén 1998–2015) appears to be a good choice. Such SEM programs offer bootstrapping as an estimation method (Cheung and Lau 2008), which we also recommend using in SEM because of the non-normal nature of the indirect effect. If bootstrapping is applied, SEM yields nearly the same results as PROCESS (for the four examples, the results in AMOS differ from the ones in PROCESS only on the third decimal). Despite the opportunities SEM presents for specifying mediation models, it also means more complexity in setup and analysis – for example, when comparing alternative models in the presence of contradicting fit indices (Iacobucci et al. 2007).
Furthermore, most of the SEM programs do not offer the full functionality of PROCESS regarding mediation analysis. For instance, while it is possible to test the total indirect effect in most of the SEM programs, parameters and confidence intervals of specific indirect effects in mediation models are usually not part of the output (exceptions are Mplus, Mx, and OpenMx; Macho and Ledermann 2011). Nonetheless, it is possible to manually implement some of the features. For example, there exists a methodology to estimate specific indirect effects in SEM programs such as AMOS, called the phantom model approach (Macho and Ledermann 2011). Macho and Ledermann’s idea for estimating a specific indirect effect is to build a separate partial model (phantom model) that mimics the full model but only encompasses the paths of the specific effect (for detailed instruction on how to build a phantom model, see Macho and Ledermann 2011). Other examples in which SEM programs do not provide as much default features as PROCESS is in the interpretation of moderated mediation (e.g., they do not yet provide an index of moderated mediation) or mediation models with multicategorical independent variables (the so-called omnibus test; Hayes and Preacher 2014). Researchers interested in these specific features in complex model settings may prefer Mplus. The syntax-based nature of Mplus makes it possible to access code concerning such advanced mediation analysis features (e.g., code for complex moderated mediation models in Hayes and Preacher 2014).

In summary, SEM is a powerful approach that can enhance mediation analysis in several ways. However, one should keep in mind that its sophistication poses several challenges and therefore inexperienced researchers might face some error potential when using it. A decision rule would be that regression-based bootstrap approaches (such as those offered by PROCESS) are preferable unless the issues described in this section become crucial.

6. Summary

The goal of this paper was to give an overview of mediation analysis. To achieve this goal, we reviewed the basic concept of mediation as well as its main elements, and we discussed how to interpret mediation results based on indirect and direct effects. We focused on simple mediation, parallel mediation, serial mediation, and moderated mediation, which represent the most common mediation model groups in marketing research. After reviewing the conceptual background of mediation analysis, we turned our attention to the methodological aspects of mediation analysis. Here, we compared three different regression-based approaches of mediation analysis. In particular, we examined the rationale of the bootstrapping approach, discussed why it yields superior results compared to traditional approaches of mediation analysis, and argued that it is particularly suitable for estimating the indirect effect. While we concentrated on conceptual and methodological considerations in the first part of the paper, the second part is organized as a tutorial. Here, we illustrated how to conduct mediation analysis and interpret the output of the SPSS/SAS macro PROCESS.

In the tutorial, we presented a typical case of more than one model specification being theoretically meaningful and recommended a hierarchical procedure. Hereby one examines simple mediation models first and, step by step, extends those simple models to more complex models. Following such a stepwise approach, we opted for inspecting the indirect effect at each step to determine whether a proposed mediator can explain the proposed causal relationship. Moreover, we recommended inspecting the direct effect to reveal to what extent the causal relationship can be explained by the mediator. This information is useful for further conceptual reasoning, and we describe a suitable framework in Section 2.3. Besides inspecting the direct and indirect effect in simple and parallel mediation, we also illustrated how to test more sophisticated hypotheses of a serial mediation model and a moderated mediation model. For the serial mediation model, we emphasized the significance of the long-way specific indirect effect as most important. For the moderated mediation model we recommended to test whether the proposed indirect effect is conditional on levels of a moderator, revealed by the index of moderated mediation. After giving detailed information on how to specify the models with PROCESS syntax and interpret the relevant elements of the PROCESS output, in the appendix we illustrated how to report results. Concluding, we hope that this review and tutorial will contribute to a consistent and cognizant use of mediation analysis.

Notes

1. Because consumer researchers frequently use mediation analysis, we added the Journal of Consumer Psychology to our list of top-tier journals.

2. In their work, Baron and Kenny (1986) describe three regression equations and thus three steps. Because the third equation is used to draw two different inferences, we refer to them as separate steps.

3. It is recommendable to also download the templates document from the website, which lists all the models PROCESS can specify (Hayes 2017). A full documentation of PROCESS is provided by Hayes (2013).

4. The data can be downloaded from: https://rsw.beck.de/zeitschriften/marketing/current-issue

5. One can find the specification for this model in the graphical user interface in Fig. 9. Note that the syntax will change with the release of PROCESS v3 (Hayes 2017).

6. Some journals, including the Journal of Consumer Research, require reporting p-values between .05 and .10 as marginally significant (Journal of Consumer Research 2011). Although some researchers argue that marginally significant results should be dismissed (Iacobucci 2005), it frequently happens that marginally significant effects are treated as “almost (highly) significant.” In the latter case, one would infer complementary partial mediation from the above results.

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Appendix

Suggestions for reporting PROCESS results (based on the data examples)

Simple mediation

We used PROCESS model 4 (Hayes 2013) to test the proposed mediation. The data is consistent with the claim that $A_{el}$ impacts $A_{prod}$, which in turn increases $PI$ ($b = .31; 95\% CI = .16$ to .49). The mediation partially explains the effect of $A_{el}$ on $PI$; in addition $A_{el}$ influences $PI$ independently from the proposed mechanism ($b = .15, p = .047$). Hence, we infer complementary partial mediation (Zhao et al. 2010).

(The reader may refer to Sch rift and Amar (2015) and Siddiqui et al. (2017) for further examples of reporting simple mediation results yielded from PROCESS in the marketing literature.)

Parallel mediation

We used PROCESS model 4 (Hayes 2013) to test the proposed mediators. Overall, we could establish a mediation of both proposed mediators, resulting in a significant mediation from $A_{el}$ to $PI$ through $A_{prod}$ ($b = .26; 95\% CI = .14$ to .43) and recall ($b = .08; 95\% CI = .02$ to .17). The proposed mediation through $A_{prod}$ is significantly stronger than the one through product recall ($A_{el} = .17; 95\% CI = .01$ to .36).

There is an insignificant direct effect of $A_{el}$ on $PI$ ($b = .12, p = .075$). Taken together, the findings indicate full parallel mediation.

(The reader may refer to Hur et al. (2015) and Winterich and Zhang (2014) for further examples of reporting parallel mediation results yielded from PROCESS in the marketing literature.)

Serial mediation

Using PROCESS model 6 (Hayes 2013) we could establish a serial mediation from $A_{el}$ through $A_{prod}$, through recall to $PI$ ($b = .05; 95\% CI = .02$ to .11). In addition, $A_{el}$ had an indirect effect on $PI$ through $A_{prod}$ ($b = .25, 95\% CI = .13$ to .41) but not through recall ($b = .03, 95\% CI = .04$ to .12). Finally, there is no direct effect of $A_{el}$ on $PI$ ($b = .12, p = .075$), indicating full serial mediation.

(The reader may refer to Hur et al. (2015) and Winterich and Zhang (2014) for further examples of reporting serial mediation results yielded from PROCESS in the marketing literature.)

Moderated mediation

We used PROCESS model 7 (Hayes 2013) to test the proposed moderated mediation. Overall, we could establish a moderated mediation from $A_{el}$ through $A_{prod}$ to $PI$, dependent on elaboration mode (index of moderated mediation: .31; 95\% CI = .06 to .63). While for the low elaboration group there is a significant indirect effect of $A_{el}$ on $PI$ through $A_{prod}$ ($b = .45, 95\% CI = .24$ to .66), the effect disappears when elaboration is high ($b = .14, 95\% CI = .07$ to .34).

(The reader may refer to Blanchard et al. (2016) and Hur et al. (2015) for further examples of reporting moderated mediation results yielded from PROCESS in the marketing literature.)

References


Keywords
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