Gray's Behavioural Inhibition System as a mediator of mindfulness towards well-being

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ABSTRACT

The objective of the study was to test whether Gray's "Behavioural Inhibition System" (BIS) is a pathway from mindfulness towards well-being in a cross-sectional and correlational design, using online data collection. We administered the Freiburg Mindfulness Inventory (FMI) and the Kentucky Inventory of Mindfulness Skills (KIMS) to a non-clinical sample of German adults ($n = 211$). BIS was measured using the Action Regulation Emotion System Questionnaire (ARES), and well-being was measured using a compound variable consisting of the Marburg Habitual Well-being Scale (MHW) along with two subscales of the Questionnaire of General Habitual Well-Being (FAHW). We analysed two mediator models with the FMI or KIMS as independent variables, respectively. In both models, BIS was modelled as a mediator, and well-being served as the dependent variable. The total effect of mindfulness on well-being was found to be strong for both models. Also, the effect of mindfulness on the proposed mediator BIS was substantial, as was the effect of BIS on well-being. The study demonstrates that BIS can partially explain the pathway between mindfulness and well-being, suggesting that BIS may be a mediator of the effects of mindfulness.

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1. Introduction

Mindfulness can be defined as a state of mind that allows focusing on the present moment with a non-judgemental or accepting attitude, embracing a warm and friendly openness and curiosity (Kabat-Zinn, 2005). It can be contrasted with states of mind where attention is focused elsewhere, including preoccupation with the past or future, and behaving automatically without awareness of one' action (Brown & Ryan, 2003). In recent years there has been a substantial clinical interest, and hence increasing ambition, to study elements of mindfulness free from cultural or religious influence (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). A growing body of studies show that mindfulness training enhances health indicators relevant to a diverse set of clinical symptoms and different populations (Grossman, Niemann, Schmidt, & Walach, 2004). The field of interest within mindfulness research has extended from conceptual and measurement questions to identifying possible mechanisms of actions of mindfulness. Correspondingly, the crucial question is which psychological processes mediate the effects of mindfulness relevant for well-being?

1.1. Existing mediation models of mindfulness

The first models explaining how mindfulness conveys its seemingly beneficial effects for health have already emerged (Ivanovski & Malhi, 2007). One of the most prominent models is the reperceiving model, proposed by Shapiro, Carlson, Astin, and Freedman (2006). The authors define reperceiving as a shift in perspective leading to a more detached sense of self, thereby also inducing secondary beneficial mechanisms of change such as clarification of personal values and better self-regulation. This model is a promising candidate in so far as it is able to explain several effects of mindfulness training including self-concept dynamisation, more positive emotions, and increased openness towards unwanted personal experiences. However, the model is still somewhat unsatisfactory in regard to its ability to explain how reperceiving and the proposed secondary mechanisms actually act on each other. Additionally, data stemming from validation studies have only partly corroborated the model (Carmody, Baer, Lykins, & Olendzki, 2009).

In summation, existing models suffer from a lack of neurobiological evidence in addition to a lack of an obvious connection to

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the theoretical underpinnings of mindfulness (i.e., Buddhist theory of mind; De Silva, 2001). This is undesirable as new models should not only build on previous research in the area of interest, but also be compatible with findings from other research fields.

1.2. Gray's "Behavioural Inhibition System" (BIS)

Buddhist philosophy as the theoretical background of mindfulness claims that aversive emotions are based on a mental process called "sankhara" (De Silva, 2001). This process can be understood as dissatisfaction with a present state of affairs; it expresses a defensive "I don't want that!" response of the individual reflected by emotional-motivational (and ultimately behavioural) responses. Mindfulness is believed to weaken the intensity of the sankhara process, thereby reducing defensive motivation and, ultimately, related aversive emotions.

We propose that the "sankhara" reactions towards aversive stimuli may be understood in psychological terms on the basis of Gray's model of the "Behavioural Inhibition System" (BIS). Gray (1994) suggested that this system, together with the "Fight-Flight-Freeze System" (FFFS) and the "Behavioural Activation System" (BAS), control the sensitivity of an individual towards signals of punishment (BIS, FFFS) and gratification (BAS), and hence also influences the propensity of an approach or avoidance motivation (for a review and new developments see Corr, 2008). Although in recent reconceptualisations FFFS alone is now responsible for mediating reactions to aversive stimuli, existing scales still do not as yet capture this change. Hence, we refer to the BIS original concept (Corr, 2004).

A substantial amount of research builds on this model, linking it to health criteria, psychopharmacology, and neurobiology (Fowles, 1980). These findings suggest that BIS plays a central role in the development of psychopathology, e.g., anxiety (Harmon-Jones, 2003).

We believe that BIS is a promising candidate as a mediator variable conveying the pathways between mindfulness and well-being. BIS builds on a large basis of well-accepted literature and fits into the existing research body, as it has been shown that mindfulness has a relieving influence on BIS-related negative emotions such as anxiety (Evans et al., 2008).

Gray (2004) proposed a hypothetical mental function, the "comparator" that distils conscious experience out of the flux of unconsciously processed data. In essence, this comparator examines the deviation of sensory data from expected and desired states – deviations and salient feedback for ongoing behaviour become, as a consequence, conscious. Such experience may indicate the presence of potential punishment stimuli – the basis for BIS behaviour. Hence, this comparator instance may be a conceptual link between consciousness and emotional reactions. Moreover, Buddhist psychology also states that the basis for emotional reactions is a comparator like process called "sanna" (De Silva, 2001). Hence, there is a substantial conceptual overlap between Buddhist psychology and Gray's model.

1.3. Aims and hypotheses

The present study aims at testing whether BIS mediates the effects of mindfulness on well-being. Fig. 1 depicts the proposed mediation model. We hypothesise that mindfulness (1) has a positive total effect on well-being, and (2) also exerts an indirect effect on well-being conveyed by the ability of mindfulness to diminish BIS, as a consequence thereby also reducing the negative effect of BIS on well-being. This model was tested using the method of Baron and Kenny (1986). Furthermore, if BIS acts as a mediator in the proposed way, group comparisons should reveal that mind-
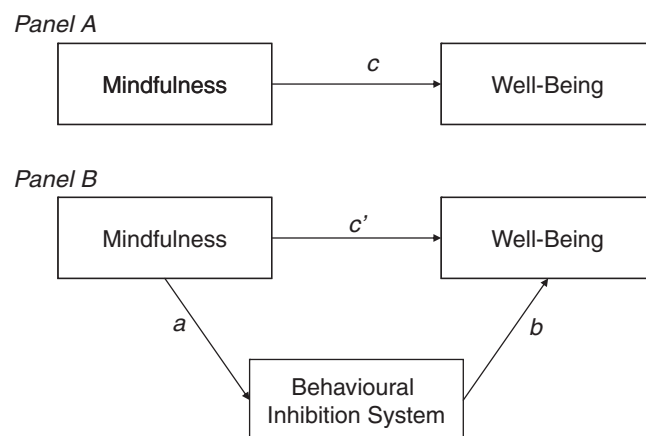

Fig. 1. Mediation model. Panel A: Illustration of total effect (path c). Panel B: Illustration of mediation effect; mindfulness affects well-being directly (path c') and indirectly through the Behavioural Inhibition System (path ab).

fulness practitioners demonstrate higher levels of mindfulness and well-being but lower levels of BIS, compared to non-practitioners.

2. Method

2.1. Sample

A questionnaire battery consisting of the measurement instruments described below was presented on a German internet research portal for mindfulness research from November 2006 to February 2007 (www.mindfulness-research.net; see procedure below). Inclusion criteria were age of 18 or older, and agreement to the informed consent and instructions. Both individuals with and without prior experience of mindfulness were explicitly addressed as participants. The sample consisted of $N = 221$ non-clinical individuals, 71% ($N = 157$) of whom were women. The mean age was 36.0 years (SD = 10.0). Forty-four percent of the subjects ($N = 97$) practiced some form of mindfulness training on a regular basis (e.g., meditation). Forty-two percent ($N = 92$) were private sector employees, 24% ($N = 52$) were students, 21% ($N = 46$) were self-employed, 3% ($N = 7$) were public sector employees, 2% ($N = 5$) were unemployed, and 9% ($N = 19$) were in unspecified employment. All participants were German.

2.2. Procedure and design

Participants were asked to answer the online questionnaire battery during a quiet moment. In order to control for multiple data submission, we checked the IP and email addresses of the questionnaires that were electronically returned. Furthermore, at the end of the questionnaire battery we confirmed with the participants that they had adhered to the instructions and had completed the questionnaires once only. There was no personal communication with the participants. Four participants were excluded as they failed to fulfil these requirements. To attract a variety of participants, the study was advertised on different websites such as student union boards, chat rooms, as well as on websites related to health and psychotherapy. To avoid self-selection bias, participants were awarded with benefits that could be seen as attractive to people with and without an interest to mindfulness. Reward consisted of course credits for psychology students, a feedback of individual mindfulness and well-being scores, and participation in a prize draw for a pocket computer. Ethical approval was obtained by our institutions' respective review boards. The design was correlational and cross-sectional.

2.3. Mediation

We employed the mediation framework advocated by Baron and Kenny (1986). Mediation, in short, refers to the pathway(s) which convey(s) the effects of an independent variable (in our case mindfulness) on a dependent variable (in our case well-being) as depicted in Fig. 1. In this terminology, the indirect effect (denoted as path *ab*) is the product of the effect from the independent variable on the mediator (denoted as path *a*) and from the effect of the mediator on the dependent variable (denoted as path *b*). The total effect (denoted as path *c*) can be understood as the sum of the direct effect of the independent on the dependent variable (controlling for the effect of the independent variable) plus the indirect effect via the mediator variable. Baron and Kenny (1986) argue for testing the paths *a*, *b*, and *c* separately to demonstrate mediation. Newer conceptual developments however, recommend testing mediation by verifying that (1) there is a significant total effect ($c \neq 0$) and that (2) there is a significant indirect effect ($ab \neq 0$) (Preacher & Hayes, 2004). We followed this recommendation as it assesses the indirect effect more efficiently, takes possible non-normal distributions into account, and has also been demonstrated to exhibit a higher power than the approach advocated by Baron and Kenny (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002).

2.4. Measures

All employed scales, including their German translations, are well validated and widely used. Internal consistency (α), as reported by the respective authors in the original validation studies, is presented for each scale. Internal consistency as found in the present data, is additionally reported in Table 1, and was found to be similar to the coefficients described by the authors of the respective scales.

2.4.1. Mindfulness

We employed two standard instruments with a somewhat different theoretical background to account for the ongoing conceptual discussion concerning mindfulness measurement. The Freiburg Mindfulness Inventory (FMI) is a 14-item self-report measure where internal consistency was found to be high ($\alpha = .87$; Walach, Buchheld, Buttenmuller, Kleinknecht, & Schmidt, 2006). It conceptualises mindfulness as a unidimensional construct with highly correlated factors of "presence" and "acceptance" (Kohls, Sauer, & Walach, 2009). The Kentucky Inventory of Mindfulness Skills (KIMS; Baer, Smith, & Allen, 2004; 39 items) assesses mindfulness with four factors ("observing", "describing", "acting with awareness", and "accepting without judgment") with acceptable to good internal consistency (from $\alpha = .79$ to $\alpha = .92$). We calculated the KIMS score as the average of factors two, three and four, and omitted the first factor of the KIMS, as previous research has pointed out that the factor "observing" is only weakly correlated with external health criteria (Ströhle, 2006).

2.4.2. Behavioural Inhibition System (BIS)

BIS was measured with subscales 1 and 2 from the Action Regulating Emotion System questionnaire – the German version of the Carver and White (1994) scales (Hartig & Moosbrugger, 2003). The authors of the Germany version report high internal consistency ($\alpha = .91$ BIS 1, and $\alpha = .92$ BIS 2, respectively). Internal validity of the scale is supported by psychometric results of exploratory and confirmatory factorial analysis (Hartig & Moosbrugger, 2003). Also, the external validity of the scale has been scrutinized in correlational and experimental studies. The scale correlated strongly with Eysenck's PEN system, as well as with sensation seeking, Big Five, PANAS and impulsivity scales (Hartig, 2003). In experimental settings, level of negative mood after mood induction was predicted by the individual BIS level (Hartig, 2003).

2.4.3. Well-being

Well-being was measured with two questionnaires. The Marburg Questionnaire of Habitual Well-Being (MHW; Basler, 1999; 7 items) measures general habitual well-being with a unidimensional factor; the author reports high internal consistency ($\alpha = .91$) and external validity with health indicators such as pain. Subjects are asked to assess a number of items referring to how they felt in the previous two weeks. A sample item is "I have enjoyed my life". Additionally, from the Questionnaire of General Habitual Well-being (FAHW; Wydra, 2003), the two subscales "psychological well-being" (7 items) and "lack of psychological well-being" (6 items) were included in the questionnaire battery. Here, subjects are asked how they feel in general. Internal consistency is found to be acceptable ($\alpha = .77$, and $\alpha = .81$, respectively).

2.5. Analyses

Data were analysed with SPPS 17. Alpha level was set to .01. For mediation analysis, we used an SPSS macro (Preacher & Hayes, 2004) which calculates the indirect effect based on a bootstrapping procedure.

In order to represent multi-faceted variables such as well-being and BIS, compound variables were computed. BIS was computed as the average of BIS 1 and BIS 2. Well-being was computed as the mean score of the two z-transformed scales Questionnaire of General Habitual Well-being and Marburg Questionnaire of Habitual Well-Being respectively (z-transformation was used for adjusting the different item ranges of the two scales). As the measurement of mindfulness is still subject to debate, we did not compute a compound variable for measuring mindfulness, but compared a model in which only the FMI mindfulness scale serves as independent variable with a model in which only the KIMS mindfulness scale was included. This is statistically justified, because the correlation of the two measurement instruments assessing mindfulness is $r = .61$, thereby indicating only 37% of shared variance.

Table 1
Means, standard deviations in full sample and subsamples (practitioners vs. non-practitioners) and coefficients for differences between the subsamples.

	Scale range	α	Mean (SD)	Mean (SD) practitioners	Mean (SD) non-practitioners	t	p	Cohen's d
Marburg Habitual Well-Being (MHW)	1–6	.90	4.37(.53)	4.63(0.96)	4.35(1.04)	−2.06	.040	0.28
Well-Being (computed as mean of FAHW and MHW)	1–6	.89	4.09(.77)	4.18(0.72)	3.99(0.82)	−1.82	.070	0.25
General Habitual Well-Being (FAHW)	1–5	.87	3.68(.71)	3.63(0.70)	3.63(0.72)	−1.06	.292	0.00
Behavioural Inhibition System (BIS)	1–4	.94	2.02(.71)	1.87(0.66)	2.20(0.73)	3.55	.000	−0.48
Freiburg Mindfulness Inventory (FMI)	1–6	.88	4.51(1.00)	4.33(0.71)	3.77(0.73)	−5.80	.000	0.79
Kentucky Inventory of Mindfulness Skills (KIMS)	1–6	.99	4.10	4.48(0.52)	4.24(0.52)	−3.43	.001	0.46

Notes. SD = standard deviation; t = t value; CI = confidence interval; α = internal consistency as found in the present data.

3. Results

3.1. Descriptive results and intrasample comparisons

As a first step, we calculated descriptive statistics and first-order correlations for all variables in the full sample (see left part of Tables 1 and 2). All correlations pointed in the expected directions ($p < .01$). Mindfulness was positively correlated with well-being, but negatively correlated with BIS. BIS was negatively correlated with both mindfulness and well-being.

In a second step, we checked if the self-report questionnaires were able to distinguish between mindfulness practitioners and non-practitioners. A negative result would invalidate the questionnaire-based mediation model. For this reason, we conducted *t*-tests for independent samples to test whether subjects practising a mindfulness training on a regular base ($n = 97$) differed in mindfulness, BIS and well-being from those not practising such a training ($n = 124$). Practitioners had a significantly higher level of self-reported mindfulness (both for KIMS and FMI), and a significantly lower level of BIS, as expected. Also, practitioners had statistically significantly higher well-being levels in the MHW scale, and a tendency for higher well-being in the FAHW scale and in the compound well-being variable (see Table 1 for details). Effect sizes (Cohen's d with pooled SD) were small for well-being, moderate for BIS and mindfulness measured by the KIMS, and large for mindfulness measured by the FMI. Taken together, these findings provide initial support for the proposed model.

3.2. Mediation models

We compared two mediation models, in both of which mindfulness served as an independent variable. Both models draw on the full sample including both practitioners and non-practitioners. In the first model the Freiburg Mindfulness Inventory (FMI) was used for operationalising mindfulness as mediator, and in the second model the Kentucky Inventory of Mindfulness Skills (KIMS) was used. In both models BIS served as mediator and well-being served as dependent variable. We have additionally tested different models, for example, one in which either only the Questionnaire of General Habitual Well-being or the Marburg Questionnaire of Habitual Well-Being was used as dependent variable. As these models did not differ significantly from those models using compound variables presented in this paper, we confine this report

accordingly. We adjusted α-$\alpha_{adj} = \alpha/4 = .002$ using a Bonferroni correction as we tested four regressions (two in each model) in order to account for alpha error inflation. As can be seen in Table 3, there was a strong and statistically significant total effect (path c) in both models, thus supporting the first of the two conditions for mediation to be established (FMI model: $\beta = .71$; SE = .07; $p < .001$; KIMS model: $\beta = .76$; SE = .09; $p < .001$). In addition, the indirect effect (path ab) was substantial and statistically significant in both models (FMI model: $\beta = .24$; SE = .05; $p < .001$; KIMS model: $\beta = .21$; SE = .06; $p < .001$). Hence, although causal conclusions cannot be inferred from the model due to its correlative design, the present results fulfil the statistical conditions for mediation. BIS serves as a partial mediator in the two present models. The direct effect (path c') was substantially weaker than the total effect but remained statistically significant (FMI model: $\beta = .47$; SE = .08; $p < .001$; KIMS model: $\beta = .55$; SE = .10; $p < .001$), thus corroborating further the presence of partial mediation.

High correlations may well indicate the presence of multicollinearity. To test for multicollinearity, we verified the Variance Inflation Factor (VIF) in the regressions in which both the independent variable as well as the mediator were included. In the FMI model, the VIF was 1.5; in the KIMS model, the VIF was 1.4. Rule of thumb guidelines state that VIF > 10 are indicative for multicollinearity (Cohen, Cohen, West, & Aiken, 2002). Thus, no evidence of multicollinearity was present in the data.

The explained variance of the dependent variable in the FMI model was $R^2 = .39$ and in the KIMS model $R^2 = 43$. These findings indicate substantial effects, with $f^2 = .63$ in the FMI model and $f^2 = .67$ in the KIMS model, respectively (Cohen, 1992). Correspondingly, power analysis revealed that the mediation analysis had a high power of 1-beta > .99 due to the large sample size and small numbers of predictors (Cohen, 1988).

As the measurement of mindfulness is still under debate, we also tested the model fit (R^2) of the two models for significant difference. For this purpose, we calculated the confidence interval of the difference of the two R^2 ($R^2_{difference} = R^2_{FMI\_model} - R^2_{KIMS\_model} = .43 - .39 = .04$) as advocated by Cohen et al. (2002). The 95% confidence interval for $n = 221$ and two predictors (mindfulness and BIS) was found to include zero: lower limit: $-.01$, upper limit: .09 (margin of error: .05). Hence, the explained variance of the two models does not differ substantially. This finding indicates that both mindfulness measures – FMI and KIMS – may be equally useful for estimating BIS as a pathway between mindfulness and well-being.

Table 2
First order correlations between scales (full sample).

	Scale	1	2	3	4	5	6
1	Kentucky Inventory of Mindfulness Skills (KIMS)	1.00					
2	Freiburg Mindfulness Inventory (FMI)	.61**	1.00				
3	General Habitual Well-Being (FAHW)	.61**	.55**	1.00			
4	Marburg Habitual Well-Being (MHW)	.47**	.45**	.62**	1.00		
5	Well-Being (mean of FAHW and MHW)	.58**	.55**	.86**	.93**	1.00	
6	Behavioural Inhibition System (BIS)	−.51**	−.57**	−.57**	−.40**	−.52**	1.00

Note. **$p < .01$.

Table 3
Coefficients of the mediation models.

Model no	IV	Total effect (path c)					Direct effect (path c')					Indirect effect (path ab)					R^2
		B	β	SE	t	p	B	β	SE	t	p	B	β	SE	t	p	
1	FMI	.65	.71	.07	9.93	.001	.43	.47	.08	5.72	.001	.22	.24	.05	4.63	.001	.39
2	KIMS	1.02	.76	.09	10.98	.001	.74	.55	.10	7.24	.001	.28	.21	.06	4.62	.001	.43

Notes. IV, Independent variable; R^2, Variance accounted for by the model; B, Unstandardised regression coefficient; SE, Standard error ; β, Standardised regression coefficient ; t, t-value ; FMI, Freiburg Mindfulness Inventory; KIMS, Kentucky Inventory of Mindfulness Skills.

4. Discussion

In this paper, we examined a possible mechanism of action in mindfulness. We have hypothesised that a reduction in BIS accounts for parts of the effect that mindfulness exhibits on well-being. Results support the proposed model. There was a strong total effect of mindfulness on well-being that underpins the clinical relevance of mindfulness. We have additionally found a strong indirect effect of mindfulness on well-being through BIS. Hence, the mediation data support BIS as a mediator of mindfulness. The results of the mediation analysis is backed by the fact that the subsamples of mindfulness practitioners had higher well-being and mindfulness scores compared to the subsamples of non-practitioners, but lower BIS scores. Taken together, our results corroborate the hypothesis that BIS may be one pathway from mindfulness towards well-being.

A potential restriction of this study is that the data was collected online. Online research is a relatively new technique for collecting data that has recently become very popular although the comparability of offline and online data is still debated (Reips, 2002). Gosling, Vazire, Srivastava, and John (2004) have conducted a review on the quality of this approach and have concluded that both online and traditional methods yield similar results. Moreover, online samples tend to be more diverse than classical samples and hence more representative for the general population. Cheating and multiple submissions are not of a high practical relevance in online research according to Gosling et al. Nevertheless, we accounted for this potential problem through various safeguards, most importantly through checking IP addresses to avoid multiple submissions. On this basis, we assume that – as a first step – our sample provides data which can be generalised to a population of non-clinical adults. Future studies should also collect data in traditional ways.

However, a few limitations of the present study need to be borne in mind. First and foremost, the study was conducted as a correlational and cross-sectional design. Thus, the design precludes strong causal conclusions. This fact needs to be highlighted because path analysis easily abets causal thinking even if such strong implications are not supported by the design.

Secondly, we investigated the effects on BIS and well-being in a sample of non-clinical adults only. It seems encouraging that expected effects were found in a sample of non-clinical adults despite the fact that the variance of well-being parameter is normally reduced in such samples (and hence effects are smaller). Future research needs to recruit clinical samples and also include additional outcome variables such as depression or anxiety.

The as yet small research body on mediators of mindfulness suffers from similar restrictions as the present study. These limitations provide avenues for future research. Therefore, future studies should explicitly take the limitations that have been discussed here into account to present more rigorous research. An ideal study to test BIS should involve an experimental design with multiple measurement points. If BIS is to be substantiated as a mediator of mindfulness, then a change in BIS is to be expected before improvements in health outcome variables are observed. Such a study should not only test one but several potential mediators simultaneously and compare the results. We recommend this design for future research as it would allow conclusive insights. As it seems highly unlikely that a complex phenomenon such as mindfulness is mediated by a single mechanism, future studies should continue scrutinising and comparing different types of mediators, including Gray's Behavioural Activation System and the reperceiving model suggested by Shapiro and colleagues.

If BIS as a mediator of mindfulness can be confirmed by future studies, then this implies that mindfulness training should be designed to enable the reduction of BIS, e.g., by including exercises that aim to reduce high sensivity to punishment. Furthermore, mindfulness training may then be considered as a remedy for individuals suffering from very high BIS levels.

To sum up, there is a clear need to further scrutinise the appropriateness of BIS as a mediator of change in mindfulness. Nevertheless, we believe that the strengths of this study – a clear, well-corroborated conceptual background model, sufficient sample size, as well as the good psychometric properties of the instruments used – outweigh its weaknesses and allow us to draw valid, albeit tentative conclusion: BIS is a promising candidate for explaining how mindfulness conveys its health relevant effects.

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