The Impact of the Appearance of Beer on its Perception

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ABSTRACT

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The appearance of beer influences the perception of its flavour. Three separate studies were performed. Two studies using United States residents comparing beers ranked for different attributes showed that differences in colour, head and levels of lacing impacted the perception of a number of other attributes. Rankings for best to worst poured, best to worst handled, best to worst brewed, best to worst head, most to least stable foam, highest to lowest quality foam, best to worst overall flavour, best to worst overall appearance, and most to least likely to buy all showed significant differences in rankings for both colour and levels of head and lacing. A third study using Scottish participants, comparing beers differing only in levels of head and lacing complements the American findings, suggesting that the appearance of a beer greatly influences consumer perception.

Key words: Colour, foam, head, perception.

INTRODUCTION

Consumers invariably link colour to the perception and acceptability of a food product. Pangborn[9] investigated the influence of colour on discrimination of sweetness. Clydesdale[4] argued that colour influences other sensory properties of a food. The cola industry realised the importance of colour in relation to their food product first hand in their unsuccessful marketing campaigns of colourless colas[3]. A "clear beer" launched in the United States was short-lived. Clydesdale[5,6] stressed that colour plays a role in food acceptability for elderly participants, demonstrating the effects of colour on thirst quenching, sweetness, acceptability, and flavour intensity in fruit punch.

Many brewing professionals argue that the consumer's perception of the colour of a beer influences their opinion about bitterness, flavour, likelihood to buy, and other features, though there is very little published literature in support of these claims. In this work a study, using a live pouring of three beer types, tested for perceived differences in beers based on differences in colour. Though some consider rating superior to ranking in terms of statistical value[7], in this study judges ranked beers for various sensory attributes, as well as for many terms popular in the trade (i.e., best to worst brewed, head, etc.). Ranking has the advantage that it is a simple task; because consumers are culturally practised at ranking, it allows participants to re-examine stimuli whose characteristics they may have forgotten[10]. By ranking the beers rather than rating them individually, this study eliminates the necessity to train judges for complex rating tasks necessary for meaningful and reliable results.

Prior studies have also addressed the effect of head and lacing on preference choices in beer[2], it seeming for the most part that beers that display stable but not excessive heads meet with greatest favour. A follow-up study[11] confirmed the findings that the levels of head and lacing are important, but further suggested some variation in head preference based upon geographic locale. For instance, Belgian consumers appeared to have a preference for high levels of head and lacing, while Scottish consumers appeared to prefer relatively lower levels of head and lacing.

The present studies represent an attempt to quantify the impact that differences in colour, head and lacing have on the perceived characteristics of a beer. Separate studies were performed, in which either colour or head and lacing levels were the variables. Preference for different levels of head and lacing by geographic locale is claimed to be divergent[1]. This study used two target populations, one each from the United States and Scotland.

MATERIALS AND METHODS

Subjects

Colour study. Eighteen subjects (11 male, seven female, ages 21–40 years) from the University of California, Davis, participated.

Head and lacing study. Forty-one subjects (27 male, 14 female, age 21–57 years) chosen at random from a dining area at the University of California, Davis, participated. Also, 50 subjects from Edinburgh, Scotland (38 male, 12 female, 21–64 years) represented a sampling from the Scottish consumer population. A regional brewery with experience in sensory work, and a university in the same city as the selected brewery, each provided half the judges for the Scottish study.

Stimuli

Colour study. This investigation focused on three beers of increasing colour intensity: a pale lager with a colour of 4.5° EBC, a slightly darker lager with a colour of 6.0° EBC, and an ale with a colour of 16.0° EBC. Colour assessment of beers is routinely on the basis of their relative absorbance at 430 nm. In this study, alphabetic identifiers

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labelled each beer: X represented the 4.5° EBC lager, Y represented the 16.0° EBC ale, and Z represented the 6.0° EBC lager. Subjects found letters simpler to use than traditional three-digit random numbers. Because the differences were easily perceptible and not likely to be confused, experimenters considered it safe to use letter codes, perceived differences in colour outweighing possible "favourite letter" bias.

Head and lacing study. Both the Scottish and American studies used the same stimuli, namely four laminated sets of true colour photographs (Fig. 1). All of the images spawned from a single domestic lager poured in various ways to create different head types on the same colour beer. For the creation of images of a beer with high levels of head and lacing, one or two drops of iso-alpha-acid extract were added to the appropriate glass before pouring. A set of black paper sheets served as the background to accentuate differences in head and lacing. Each set of images had an alphabetic identifier, and represented beers at three stages of consumption: full, half-full, and empty. The photographic sets represented four beer types: low head with light lacing, moderately low head with moderately light lacing, moderately high head with moderately heavy lacing, and high head with heavy lacing. For American participants, these beers carried the designations of W, X, Y, and Z, respectively, and were presented to judges in random 2x2 arrays. American judges often repositioned the images to their liking. For the Scottish participants, the images carried three-digit random numbers and were presented in random 2x2 arrays to judges. Most Scottish participants would re-arrange the images in the same manner as the American participants, regardless of the three-digit random numbers on the images themselves, based upon levels of head and lacing. This suggests that the ease of differentiating the images overcame any possible favourite letter bias in the American sample.

FIG.1 Images used in the foam and lacing studies for American and Scottish participants. Image (W) represents a beer with low head and light lacing; (X) represents a beer with moderately low head and moderately light lacing; (Y) represents a beer with moderately high head and moderately heavy lacing; (Z) represents a beer with high head and heavy lacing.

Experimental design and protocol

Colour study. The colour study began with a live pouring of three beers into unused, clean Pilsner-style glasses. For each beer, the first glass was filled and emptied, the second glass was filled and emptied only halfway, and the third glass was filled and was maintained full. This gave nine Pilsner glasses with three different levels of a trio of beers. The poured beers exhibited similar levels of head and lacing, though, as one would expect from different beers, the heads did have somewhat different bubble size distributions, though the differences were not excessive. Presentation of the glasses was on a table in the sequence of empty, half-full, and full in three columns with each column representing one beer colour. A handout asked participants to rank the three beer types for a number of attributes, listed below. The subjects could approach, but not touch, the samples during the experiment.

TABLE I. Rank totals, groupings, and significance levels for colour study.

Beer Attributes	Newell-MacFarlane Rank Sums[1] X	Y	Z	Judges	Groupings	Significance
Best to worst poured	38	19	39	16	$Y^a X^b Z^b$	p<0.01
Best to worst handled	37	21	38	16	$Y^a X^{ab} Z^b$	p<0.01
Best to worst brewed	36	21	39	16	$Y^a X^{ab} Z^b$	p<0.01
Best to worst head	36	18	42	16	$Y^a X^b Z^b$	p<0.01
Most to least carbonated	34	35	27	16	$Z^a X^a Y^a$	NS diff
Most to least stable foam	41	17	38	16	$Y^a Z^b X^b$	p<0.01
Highest to lowest quality foam	39	17	40	16	$Y^a X^b Z^b$	p<0.01
Cleanest to dirtiest glass	30	30	36	16	$\underline{X^a\ Y^a}\ Z^a$	NS diff
Most to least fresh	35	21	40	16	$Y^a X^{ab} Z^b$	p<0.01
Most to least thirst quenching	30	35	31	16	$X^a Z^a Y^a$	NS diff
Most to least bitter	43	21	32	16	$Y^a Z^{ab} X^b$	p<0.01
Most to least sweet	32	35	29	16	$Z^a X^a Y^a$	NS diff
Most to fewest off-flavours	35	35	26	16	$Z^a\ \underline{X^a\ Y^a}$	NS diff
Best to worst overall flavour	38	19	39	16	$Y^a X^b Z^b$	p<0.01
Highest to lowest alcohol content	42	20	34	16	$Y^a Z^{ab} X^b$	p<0.01
Best to worst overall appearance	41	17	38	16	$Y^a Z^b X^b$	p<0.01
Greatest to worst drinkability	35	24	37	16	$Y^a X^a Z^a$	NS diff
Most to least likely to buy	32	15	37	14	$Y^a X^b Z^b$	p<0.01

[1] X represents the 4.5° EBC lager; Y represents the 16.0° EBC ale; Z represents the 6.0° EBC lager.
Beers with different superscripts are significantly different at the significance levels noted; those with the same superscript are not significantly different. Underlining indicates beers that have the same Newell-MacFarlane rank sums. Beers with lower rank sums than beers with higher rank sums represent beers that are perceived to be greater, higher, more, or better for the given attribute.

Subjects ranked beers for up to 18 attributes based on visual assessment alone. The attributes were: quality of pouring, quality of handling, quality of brewing, quality of head, extent of carbonation, stability of foam, quality of foam, cleanliness of glass, extent of freshness, perceived thirst quenching character, extent of bitterness, extent of sweetness, level of off-flavours, quality of overall flavour, amount of alcohol, quality of overall appearance, extent of drinkability (defined on forms as "the likelihood to consume multiple beers in a single sitting"), and likelihood of buying. One set of beers was poured and all participants observed the beers simultaneously. Test times ranged from 6 to 12 min. An experimenter helped with any confusion during the questionnaire.

Head and lacing study. Subjects ranked beers for up to nineteen attributes based on visual assessment only. The attributes in question were the same as those in the colour study, with the addition of the attribute quality of aroma. Occasionally, subjects would leave attributes unranked, commenting that they were unable to rank that attribute given the limitations of the stimuli (i.e., photos do not predict aroma). Subjects were tested individually by the experimenter to help avoid confusion. Test times ranged from 7 to 15 min.

Data analysis

Statistical analysis of rankings was performed using the Newell-MacFarlane Two-Factor Ranked ANOVA[8] to analyse the ranking data to determine whether any apparent consistent differences existed among the beers.

RESULTS

Colour study

The results of the colour study are shown in Table I. For the colour study, the letter X represents the 4.5° EBC lager, Y represents the 16.0° EBC ale, and Z represents the 6.0° EBC lager. The 16.0° EBC ale (Y) ranked "highest," "best," or "most" in every category where significant differences existed, while the lighter beers never significantly differed in any of the attributes in question. The 16.0° EBC beer (Y) ranked better poured, with a better head, better foam stability, better foam quality, better in anticipated flavour, better in overall appearance, and more likely to be bought as compared to either of the lagers. It ranked as significantly better handled, better brewed, and fresher than the 6.0° EBC lager (Z). It also ranked significantly higher in anticipated bitterness and alcohol content than the 4.5° EBC lager (X). Examining Table I, it can be seen that no significant differences existed among different coloured beers for perception of level of carbonation, cleanliness of glass, perceived thirst quenching ability, sweetness, number of off-flavours, and drinkability.

American head and lacing study

The interpretation of the results from the head and lacing study is more varied and convoluted than the results of the colour study. Table II displays the results for the American study, with the letters W, X, Y, and Z representing the beer types discussed in the methods section. The more facile analyses of a number of attributes reveal that no significant differences existed among beers with different levels of head and lacing for aroma, freshness, bitterness, sweetness, and presence of off-flavours. Beer Z, with the highest levels of head and lacing, ranked significantly worse handled and less drinkable than the other beers used in the study. Beer Z also predictably ranked significantly higher in level of carbonation than the other beers, while Beer W, with the smallest head and least lacing, ranked significantly lower.

Less clear distinctions arise from the other attributes, though one may observe clear trends. For instance, beers

TABLE II. Rank totals, groupings, and significance levels for American head and lacing study.

Beer Attributes	Newell-MacFarlane Rank Sums[1]				Judges	Groupings	Significance
	W	X	Y	Z			
Best to worst poured	96	69	84	121	37	X^a Y^a W^{ab} Z^b	p<0.01
Best to worst handled	78	65	81	116	34	X^a W^a Y^a Z^b	p<0.01
Best to worst brewed	104	67	77	92	34	X^a Y^{ab} Z^{ab} W^b	p<0.01
Best to worst head	116	70	66	98	35	Y^a X^a Z^{ab} W^b	p<0.01
Most to least carbonated	122	89	83	46	34	Z^a Y^b X^b W^c	p<0.01
Most to least stable foam	125	90	82	73	37	Z^a Y^a X^{ab} W^b	p<0.01
Highest to lowest quality foam	112	64	66	98	34	Y^a X^a Z^{ab} W^b	p<0.01
Cleanest to dirtiest glass	80	58	61	91	29	X^a Y^{ab} W^{ab} Z^b	p<0.01
Best to worst aroma	85	85	90	100	36	NS diff	NS diff
Most to least fresh	96	73	70	81	32	NS diff	NS diff
Most to least thirst quenching	76	60	67	97	30	X^a Y^{ab} W^{ab} Z^b	p<0.01
Most to least bitter	71	57	63	69	26	NS diff	NS diff
Most to least sweet	73	57	63	67	26	NS diff	NS diff
Most to fewest off-flavours	62	71	74	63	27	NS diff	NS diff
Best to worst overall flavour	86	53	59	82	28	X^a Y^{ab} Z^{ab} W^b	p<0.01
Highest to lowest alcohol content	50	54	59	77	24	W^a X^{ab} Y^{ab} Z^b	p<0.05
Best to worst overall appearance	102	67	82	119	37	X^a Y^{ab} W^{bc} Z^c	p<0.01
Greatest to worst drinkability	82	55	73	110	32	X^a Y^a W^a Z^b	p<0.01
Most to least likely to buy	106	59	81	124	37	X^a Y^a W^{ab} Z^b	p<0.01

[1] Beer W represents a beer with low head and light lacing; Beer X represents a beer with moderate low head and moderately light lacing; Beer Y represents a beer with moderately high head and moderately heavy lacing; Beer Z represents a beer with high head and heavy lacing.
Beers with different superscripts are significantly different at the significance levels noted; those with the same superscript are not significantly different. Beers with lower rank sums than beers with higher rank sums represent beers that are perceived to be greater, higher, more, or better for the given attribute.

with moderately high or low levels head and lacing (Beers X and Y) rank higher for perceived foam quality than beers with low levels of lacing and head (Beer W). American participants considered beers with high levels of head and lacing less well poured, in dirtier glasses, and less likely to be purchased than beers with moderate levels of head and lacing. Perceived foam stability also shows a strong association with the levels of the head and lacing present in the glass, while perceived alcohol content shows an inverse correlation to the levels of head and lacing in the glass. A final distinction can be made regarding moderately high or low levels of head and lacing, which participants perceive as better in overall appearance than beers with high levels of head and lacing.

It is more difficult to interpret the meaning of the results for quality of brew, thirst-quenching attributes, and overall flavour. At best, it can be seen statistically that judges viewed low levels of head and lacing as being less well brewed and worse in overall flavour than a beer with moderately low levels of head and lacing. One may also report that the American participants surveyed perceive beers with high levels of head and lacing as less thirst quenching than beers with a moderately high or low levels of head and low lacing.

Scottish head and lacing study

Table III summarises the results from the Scottish head and lacing study. Again, the letters W, X, Y, and Z represent the four beer types listed in the Methods section. Although the Scottish judges ranked the images using three-digit random numbers, the numbers have been converted to match the designations used in the American study for the purposes of this analysis.

There were no significant differences caused by different levels of head and lacing on the attributes of best to worst aroma and highest to lowest alcohol content, as well as for most to least bitter and most to least sweet.

In analysing these results, one can consider clear divisions in rankings most easily in those cases in which no groupings overlap. This occurs in five of the remaining attributes: best to worst poured, most to least carbonated, most to least stable foam, most to least fresh, and most to least thirst quenching. In the case of best to worst poured, judges considered the beer with high levels of head and lacing to be the worst poured, while the beer with moderately low levels of lacing and head as the best poured. Judges considered the beer with low levels of head and lacing and the beer with moderately high levels of head and lacing as significantly different from the other two beers, less well poured than beer X (moderately low head, lacing), but better poured than beer Z (high head, lacing). A similar overall ranking scheme is observable for the attribute of most to least thirst quenching potential, with these participants considering the beer with the highest levels of head and lacing to be the least thirst quenching. The other three beers showed no difference in significance in terms of thirst quenching potential. These results further suggest perceived thirst quenching potential may be an indicator of quality, matching the ranking schemes of the attributes regarding drinkability, overall appearance, and purchase intent. The attribute of most to least fresh suggests that these participants view a beer with low head and lacing as less fresh than the other beers viewed, which may be compared to the findings of the attributes of most to least carbonated and most to least stable foam. Beers with higher levels of head and lacing tend to be ranked significantly better for these attributes when contrasted with beers with lower levels of head and lacing.

Beyond the attributes already discussed, analysis of these results becomes more complicated due to grouping overlap. Perhaps the most common groupings suggest these participants view the beer with moderately low head and lacing significantly better handled, better brewed, better in overall flavour, better in overall appearance, and

TABLE III. Rank totals, groupings, and significance levels for Scottish head and lacing study.

Beer Attributes	Newell-MacFarlane Rank Sums[1]				Judges	Groupings	Significance
	W	X	Y	Z			
Best to worst poured	128	80	121	171	50	$X^a\ Y^b\ W^b\ Z^c$	p<0.01
Best to worst handled	132	91	114	143	48	$X^a\ Y^{ab}\ W^b\ Z^b$	p<0.01
Best to worst brewed	144	90	113	143	49	$X^a\ Y^{ab}\ Z^b\ W^b$	p<0.01
Best to worst head	156	76	111	147	49	$X^a\ Y^{ab}\ Z^{bc}\ W^c$	p<0.01
Most to least carbonated	182	139	98	81	50	$Z^a\ Y^a\ X^b\ W^c$	p<0.01
Most to least stable foam	170	118	126	76	49	$Z^a\ X^b\ Y^b\ W^c$	p<0.01
Highest to lowest quality foam	162	80	110	128	48	$X^a\ Y^{ab}\ Z^{bc}\ W^c$	p<0.01
Cleanest to dirtiest glass	154	109	109	128	50	$\underline{X^a\ Y^a}\ Z^{ab}\ W^b$	p<0.01
Best to worst aroma	110	110	129	141	49	$\underline{W^a\ X^a}\ Y^a\ Z^a$	NS diff
Most to least fresh	159	109	117	115	50	$X^a\ Z^a\ Y^a\ W^b$	p<0.01
Most to least thirst quenching	121	96	119	164	50	$X^a\ Y^a\ W^a\ Z^b$	p<0.01
Most to least bitter	128	129	112	131	50	$Y^a\ W^a\ X^a\ Z^a$	NS diff
Most to least sweet	126	121	128	125	50	$X^a\ Z^a\ W^a\ Y^a$	NS diff
Most to fewest off-flavours	106	145	132	117	50	$W^a\ Z^{ab}\ Y^{ab}\ X^b$	p<0.05
Best to worst overall flavour	150	93	116	141	50	$X^a\ Y^{ab}\ Z^b\ W^b$	p<0.01
Highest to lowest alcohol content	115	112	130	143	50	$X^a\ W^a\ Y^a\ Z^a$	NS diff
Best to worst overall appearance	146	87	117	150	50	$X^a\ Y^{ab}\ W^b\ Z^b$	p<0.01
Greatest to worst drinkability	137	87	118	158	50	$X^a\ Y^{ab}\ W^b\ Z^b$	p<0.01
Most to least likely to buy	148	86	111	155	50	$X^a\ Y^{ab}\ W^{bc}\ Z^c$	p<0.01

[1] Beer W represents a beer with low head and light lacing; Beer X represents a beer with moderate low head and moderately light lacing; Beer Y represents a beer with moderately high head and moderately heavy lacing; Beer Z represents a beer with high head and heavy lacing.
Beers with different superscripts are significantly different at the significance levels noted; those with the same superscript are not significantly different. Underlining indicates beers that have the same mean ranks.

with greater drinkability than the beers with high or low levels of head and lacing. None of the beers is significantly different from the beer with moderately high levels of head and lacing for these attributes. Analysis of the attribute of cleanest to dirtiest glass reveals that participants consider beers with low levels of head and lacing likely to be in dirtier glasses than those with moderately high or low levels of head and lacing, with none of the beers being significantly different from the beer with high levels of head and lacing.

These participants consider the beer with moderately low levels of head and lacing to have significantly better head, higher foam quality, and higher purchase intent than the beers with high or low levels of head and lacing. Conversely, in the case of best to worst head and highest to lowest quality foam, the beer with low head and lacing ranks significantly worse than beers with moderately low and high levels of head and lacing. For the concept of most to least likely to buy, the beer with the high levels of head and lacing ranks significantly lower than beers with moderately low or high levels of head and lacing.

DISCUSSION

Colour study

The differences found in this study show these participants ranked the 16.0° EBC ale as better poured, with a better head, better foam stability, better foam quality, better in anticipated flavour, better in overall appearance, and more likely to be bought as compared to either of the lagers. It ranked as significantly better handled, better brewed, and fresher than the 6.0° EBC lager (Z). It also ranked significantly higher in anticipated bitterness and alcohol content than the 4.5° EBC lager (X). It could be claimed that because this was a live pouring, differences in bubble size distributions inherent in the beers themselves cast uncertainty as to whether the differences detected in these attributes arose purely from differences in colour. However, during beer selection, experimenters were careful to choose beers based upon similarity of bubble size distribution and foam stability. A second possible point of contention is the degree of difference between beers in terms of colour intensity: it may have been that the judges automatically considered the lagers as one beer type and the ale as another, even though the two lagers differed in colour. This amounts to comparing apples and oranges. The fact that the two lagers never significantly differed in any attributes in question supports such a possibility.

American head and lacing study

Perhaps one of the most interesting pieces of information is that beer X (moderately low head and moderately light lacing) and beer Y (moderately high head and moderately heavy lacing) never showed significant differences from each other for any of the attributes in question at any significance level. Beers with moderate levels of head also ranked significantly better for quality of head and foam quality than the other beers and ranked as more likely to be bought than beers with high levels of head and lacing. These results suggest that moderate levels of head and lacing may elicit higher rankings than extreme levels of head and lacing for general indicators of quality and purchase intent for this group of American participants. This sampling may indicate that for general acceptance in the American audience, brewers should strive for moderation in head and lacing. However, to ensure acceptance for a given population, brewers should sample directly from their target audience, given claims of regional specificity for preference.

Low levels of head and lacing were associated with low alcohol content and vice-versa. However, the beer with the highest head and lacing ranked as having a dirtier glass than the beers with moderate levels of head and lacing. This perception contradicts accepted wisdom that dirty glasses destabilise foam and implies a misconception within the consumer population.

Scottish head and lacing study

Analysis of the rankings of most to least bitter, most to least sweet, best to worst aroma, and highest to lowest alcohol content all showed no significant differences among different levels of head and lacing among Scottish judges. This implies that differing levels of head and lacing do not influence the predicted nature of basic taste and olfactory sensations among Scottish participants, nor does it appear to affect the predicted alcohol content of a beer. Still, the adage that "consumers drink with their eyes" is supported by differences in predictions for best to worst flavour. The effect on perceived levels of off-flavours is not particularly significant, with this sampling of Scottish participants viewing beers with low levels of head as being significantly more likely to have off-flavours when compared to the beer with moderately low levels of head and low lacing.

Consumers will likely associate high levels of head and lacing on lagers with a highly carbonated beer and stable foam. Although the levels of carbonation, and in some cases foam stability, are not necessarily correlated with the greatest initial head or total lacing in the trade, it is important to recognise that such a correlation may exist in the consumer's mind.

Findings that participants viewed the beer with moderately low levels of head and lacing significantly better handled, better brewed, better in overall flavour, better in overall appearance, and with greater drinkability than the beers with high or low levels of head and lacing offer great insight into the Scottish consumer's mind. Each of these attributes can be considered an indicator of quality, and results of this study clearly indicate that for these particular attributes the Scots in this study perceive moderately low levels of head and lacing as optimum and excessively high or low levels as less desirable. The attributes of best to worst head, highest to lowest quality foam, and most to least likely to buy further suggest the preference for moderation in head and lacing over extreme levels for Scottish consumers.

CONCLUSIONS

Consumers make judgements of certain quality attributes of beer on the basis of their visual assessment of the

product. It is striking that the American and Scottish participants in this study believed head and lacing patterns predicted similar attributes. It is also important to remember in this context that regional preferences for head and lacing influence rankings, and sampling of specific audiences may be necessary to characterise a given consumer population.

Although within the population studied here clear differences existed in judgement of beers possessing different colours, in future studies a larger consumer population could reveal more information about the general population. In this sense, researchers need to invoke a standardised method for sampling random participants from the population of interest.

In future head and lacing studies, the most important task may be to test additional populations. Regional differences in head and lacing preference may influence many of the quality factors ranked in this study. By fully documenting regional preference differences, it may be possible to determine if any of the attributes ranked in these studies relate to beer perception universally.

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